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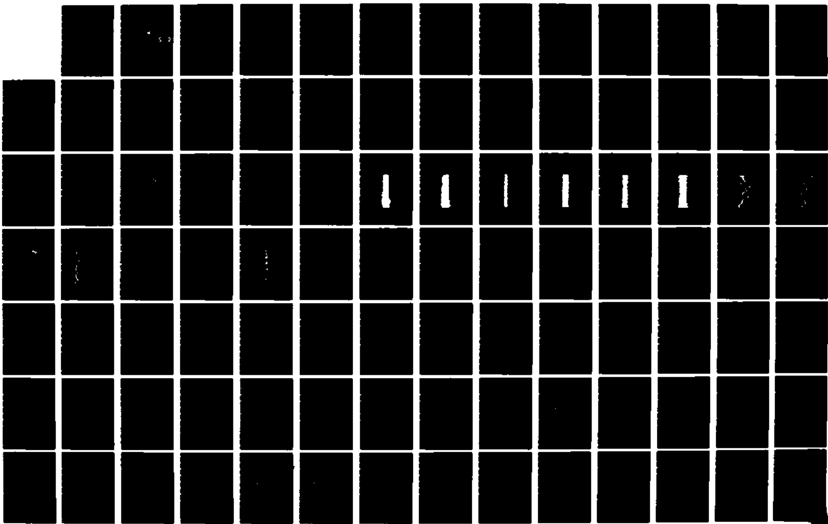

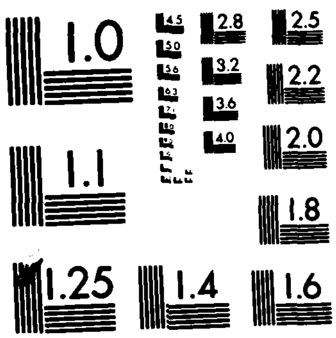

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

COHERENCE STUDY OF GEOMAGNETIC FLUCTUATIONS
IN FREQUENCY RANGE .04 - 0.6 HZ
BETWEEN REMOTE LAND SITES

by

Stephen John Anthony

December 1983

Thesis Advisor: Andrew R. Ochadlick, Jr.

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Fluctuations in the geomagnetic field were measured by three orthogonally mounted coil sensors at two land sites separated by 40 km. Computer generated voltage vs time and magnetic field vs time plots failed to reveal the presence of dominant micropulsations. A coherence study between the two sites revealed coherence values of 0.6 - 0.8 in the frequency range 0.04 - 0.6 Hz. This is compared to a coherence study completed at the Naval

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20. Abstract (continued)

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Coherence Study of Geomagnetic Fluctuations in Frequency Range .04 - 0.6 Hz Between Remote Land Sites

by

Stephen John Anthony
Lieutenant, United States Navy
B.S., University of Minnesota, 1973

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN PHYSICS

from the

NAVAL POSTGRADUATE SCHOOL
December 1983

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Dean of Science and Engineering

ABSTRACT

Fluctuations in the geomagnetic field were measured by three orthogonally mounted coil sensors at two land sites separated by 40 km. Computer generated voltage vs time and magnetic field vs time plots failed to reveal the presence of dominant micropulsations. A coherence study between the two sites revealed coherence values of 0.6 - 0.8 in the frequency range 0.04 - 0.6 Hz. This is compared to a coherence study completed at the Naval Air Development Center, Warminster, Pennsylvania, between land sites 24.8 km apart. The NADC coherence values are lower (0.3 - 0.6).

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I am indebted to my advisor, Dr. Andrew Ochadlick, for his guidance and assistance during this project. Special thanks is extended to Mr. Robert Smith for his advice and technical expertise in the calibration and operation of the electronic components used.

I. INTRODUCTION

This thesis is part of an ongoing effort at the Naval Postgraduate School to analyze ULF geomagnetic noise and micropulsations. These variations in the geomagnetic field are of interest both from a geophysical and a military viewpoint. Applications of interest to the Navy are in the areas of magnetic detection of submarines, mine warfare and communications systems.

The specific objectives of this study were to install and operate a simultaneous data collection system at two separated land sites, to modify and adapt previously developed software for data analysis and to obtain spectral coherences between the two sites for background noise and/or micropulsations.

A coherence study of background noise with background noise, of micropulsation with micropulsation and of background noise with micropulsation between the two sites should further the understanding of the types and extent of the sources that produce these fluctuations.

The data collection sites were separated by a distance of 40 km (see Appendix A). One site was at La Mesa Village, near the Naval Postgraduate School campus, while the other was at the Chew's Ridge fire lookout. The latter was chosen for its remoteness from the local power grid.

II. BACKGROUND

A. MICROPULSATIONS

The frequency spectrum of the geomagnetic field observed on or near the earth's surface has a number of well defined peaks, corresponding to categories of regular geomagnetic micropulsations, as shown in Figure 2.1. These micropulsations are designated as Pc1, Pc2, ... Pc5.

Another category of micropulsations encountered is irregular pulsations. Unlike regular Pc micropulsations, which have relatively well defined frequencies, the Pi micropulsation consists of a spectral band of noise.

The source of these micropulsations appears to be magneto-hydrodynamic resonances in the earth's magnetosphere (Pc2 - Pc5), ion cyclotron wave-particle interaction in the magnetosphere (Pc1) and ionospheric currents perturbed by conductivity variations (Pi). References 1 and 2 give more detailed explanations of these mechanisms. Micropulsations are classified as follows:

1. Pc1: (0.2 - 5 Hz frequency)

Known as "Pearls", these micropulsations are generated by the cyclotron instability of energetic protons. They have been positively correlated with solar disturbances and occur during daylight hours in the auroral zone and

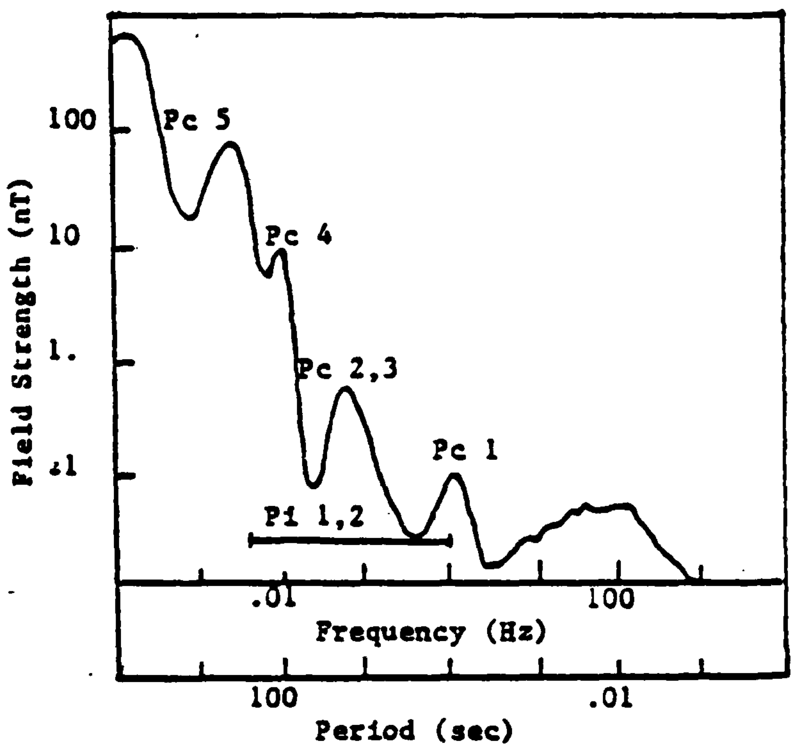


Figure 2.1 Field Strength of Micropulsations.

during night and early morning hours in the midlatitudes. Typical amplitudes are 0.05 - 0.1 nanotesla.

2. <u>Pc2: (0.1 - 0.2 Hz frequency)</u>

This is a diurnal phenomenon that shows some positive correlations with solar activity and the seasons. They usually decrease in their period as magnetic activity increases. Their average amplitude is 0.1 - 1 nanotesla.

3. <u>Pc3: (0.022 - 0.1 Hz frequency)</u>

These are similar to Pc2 pulsations except for the frequency range.

4. <u>Pc4: (6.7 - 22 mHz frequency)</u>

Sunspot activity appears to have an effect on Pc4 pulsations. Their frequency varies with the season and they have an average amplitude of 5 - 10 nanotesla.

5. <u>Pc5: (1.7 - 6.7 mHz frequency)</u>

These large scale pulsations occur during morning and evening with amplitudes of 10 - 100 nanotesla. Their duration shows a strong geomagnetic latitude dependence.

6. <u>Pil: (0.025 - 1 Hz frequency)</u>

These pulsations usually occur at night and early morning and vary in intensity from 0.01 - 0.1 nanotesla. They demonstrate a positive correlation with auroral disturbances.

7. Pi2: (6.7 - 25 mHz frequency)

The amplitude of these pulsations ranges from 1 - 5 nanotesla. They usually occur during early morning hours but may continue throughout the night. The frequencies of these pulsations increase with increasing magnetic activity.

Geomagnetic micropulsations can be distinguished from the general noise background of the geomagnetic field. The micropulsation events rise out of the ever present background activity, reach an amplitude that can be large in comparison to the background level, and then finally disappear into the background. The Pc4 and Pc5 pulsations can last several hours. However, the Pc1 - Pc3 and Pi micropulsations have a maximum duration of approximately one hour but may last only a few minutes.

B. GEOMAGNETIC BACKGROUND NOISE

It has been speculated that the primary source of the geomagnetic background noise is fluctuations in the interplanetary magnetic field [Ref. 3]. If so, a source of such large spatial extent implies that the amplitude of the background noise may be less variable over the surface of the earth than the more locally generated micropulsations, and one could expect considerable spatial coherency of the background noise over the earth's surface.

David and Heirtzler [Ref. 4] studied the coherence of geomagnetic variations between two stations up to 550 km apart. The geomagnetic variations were separated into a background noise component and a micropulsation component. When two different micropulsation types occurred simultaneously, they were found to be incoherent with one another and with the background noise. It would thus appear that independent generation mechanisms exist for the background noise component and for micropulsations of different types. Also, the background component showed association with the solar quiet day magnetic variation (Sq). In particular, the spectrum amplitude of the background component increased as the strength of Sq increased.

III. DATA COLLECTION SYSTEM

A. EQUIPMENT DESCRIPTION

The system used at both the Chew's Ridge and La Mesa Village sites is shown in Figure 3.1. The major components are:

(1) Coil sensors

(2) Preamplifiers

(3) Signal conditioner

(4) Pulse Code Modulation (PCM) encoder

(5) WWV radio receiver

(6) Tape recorder

(7) Power source

For a geographical description of the two sites, see Appendix A.

1. Coil Sensors

Each coil is continuously wound with 5460 turns of 18 gauge copper magnet wire. It has an internal resistance of 9.31 Henries. At each site, the three coils were mounted orthogonally, with the x coil oriented towards magnetic north, the y coil towards magnetic east and the z coil vertically downwards.

2. Preamplifiers

The preamplifiers are model 13-10A low noise amplifiers manufactured by Dr. Allen Phillips of SRI

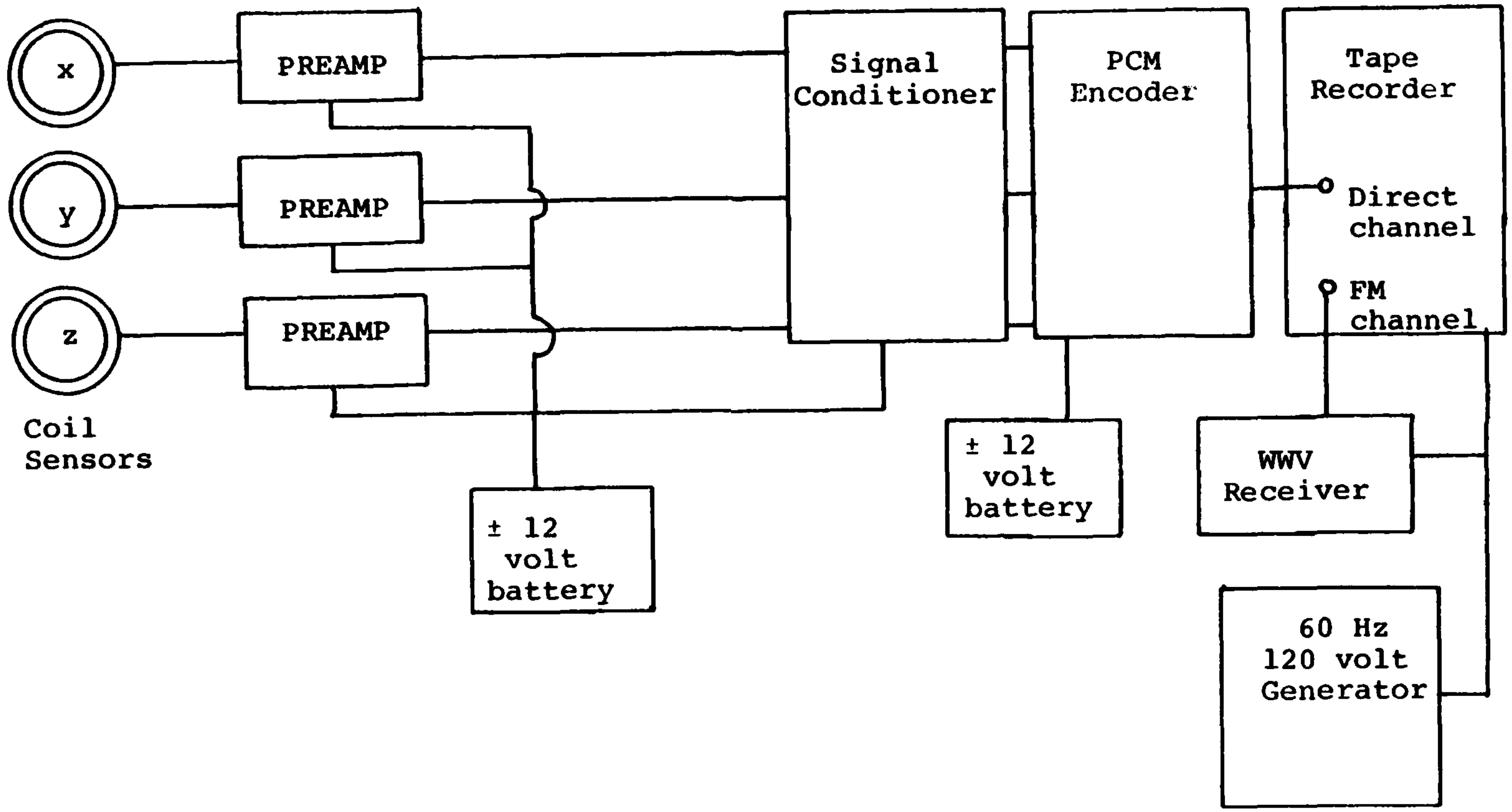


Figure 3.1 Block Diagram of Data Collection System.

International. The overall power gain is 60 dB for inputs less than 2.5 mV. A final stage low pass filter which provides a sharp cutoff at 20 Hz is provided. Each preamplifier has a DC offset potentiometer which must be adjusted to provide the correct zero-level at the output.

3. Signal Conditioner

The signal conditioner receives the analog signals from the preamplifiers, amplifies them by 30 dB and limits them to an amplitude of 7.5 volts.

4. PCM Encoder

The pulse code modulation (PCM) was designed and manufactured by Dr. Robert Lowe of Lowecom Incorporated and of the Scripps Institute of Oceanography in La Jolla, California. The encoder features 15 channel analog input capability with selectable sample rates of 2^n samples per second, where n is an integer value of 3 to 7. For the purposes of this thesis only 3 of the input channels were utilized (1, 2 and 3 for the x, y and z channels, respectively), and a sample rate of 64 samples per second was chosen to ensure adequate measurement of frequencies below 0.1 Hz. The encoder samples the analog signal from [illegible] channel at a rate of 64 Hz and assigns a pulse coded [illegible] word with a decimal value between 0 and 4096 to each sample, corresponding to an amplitude of -5 to +5 volts. The output data is organized into frames, each

frame headed by a synch code word which is followed sequentially by the pulse coded samples from input channels 1 through 15. The synch code word is a pulse coded digital word with a decimal value of between 0 and 4096. This word is preselected and hardwired on the encoder circuit board. Reference F explains the PCM system in more detail.

5. <u>WWV Radio Receiver</u>

In order to ensure that the data from the two sites was analyzed simultaneously, an R-1051 B/URR radio receiver was used to monitor the WWV Universal Time broadcast at 20 MHz at each site. The broadcast gives the Universal Time at each minute by voice with each second marked by a tone.

6. <u>Tape Recorder</u>

Hewlett-Packard HP3964A/3968A tape recorders were used to record the PCM data and WWV broadcast on analog magnetic tape. The output from the PCM encoder was recorded on a direct channel (100 - 16000 Hz frequency response) and the WWV time signal was recorded on an FM channel.

7. <u>Power Source</u>

At the Chew's Ridge site the power source used was a 3500 watt, 60 Hz, 120 volt, gasoline powered, portable generator. The separation between the sensor coils and instrumentation was about 100 feet, and between the sensor coils and portable generator approximately 250 feet. Commercial 60 Hz power was available at the La Mesa Village site.

The preamplifiers, signal conditioners and PCM encoders were powered by rechargeable 18 amp-hour batteries (plus and minus 12 volts and ground).

B. PCM TO DIGITAL CONVERSION

The PCM data recorded on analog tape is played back into a PCM decoder which converts it to digital data. The digital data is recorded in 9-track, 800 bits per inch computer tape for subsequent analysis on the IBM 3033 mainframe computer. Appendix B contains a step-by-step procedure for the decoding process.

By listening to the FM channel carrying the WWV time signal over a speaker, the point on the analog PCM tape where it is desired to begin and stop the decoding process may be precisely determined. In this manner it is possible to obtain time synchronized digital computer tapes of data from the two sites.

IV. COMPUTER SOFTWARE

The computer programs used to analyze the data are written in Fortran IV programming language and are briefly discussed below. These programs are listed in Appendices C - G.

A. PROGRAM VOLTR

The VOLTR program reads data from a digital computer tape and generates a voltage vs time plot for each orthogonal axis. The data is read from the tape in blocks of 8192 frames (128 seconds) by the subroutine RD. This data, which is in integer form between 0 to 4096, is then normalized to represent voltages between ± 5 volts. The amount of data plotted is an integer increment of 128 seconds, the integer being from 1 to 8 and specified by the user.

B. PROGRAM VODIG

This program applies a 144 point double running average and a .04 - 0.6 Hz digital filter to the rough voltage and generates filtered voltage vs time plots for each axis. The digital filter simulates the pass band of an AN/SQ-81 magnetometer and was developed by Mike Huete of the Naval Postgraduate School. Reference 5 explains the filter in detail. The double running average smooths out any large noise "spikes" that may cause an unnatural oscillatory

response in the digital filters. It also acts as a low pass filter, removing frequencies greater than approximately 1 Hz.

C. MASS STORAGE PROGRAM

In order to compare simultaneous data from two different computer tapes, the data is read from one tape (La Mesa Village), normalized to voltage values and stored in the IBM 3033 Mass Storage System, where it is available for future recall.

D. PROGRAM MAGFLD

This program generates magnetic field vs time plots. The digital data is read from the computer tape and normalized to voltage values. A Fourier transform is performed on the data to enter frequency space. At this point the system transfer function, which converts the data from voltage to magnetic field values, is applied. References 6 and 8 detail the procedures used to determine the transfer function for each coil sensor-amplifier subsystem. After the transfer function has been applied, a second Fourier transform is performed to return the data to time space. A 144 point double running average is then applied to the magnetic field data to remove frequencies above about 1 Hz.

B. PROGRAM COHER

This program calculates the spectral coherence of the total field between the two sites and the power spectral densities of the total field at each site. The La Mesa Village data previously stored in the Mass Storage System is recalled, the corresponding Chew's Ridge data is read from a computer tape, and the two data sets manipulated simultaneously.

Referring to Figure 4.1, the total field was calculated as

$$\text{total field} = x\cos\theta_d + z\sin\theta_d$$

where θ_d is the magnetic dip angle, which in the Monterey area is 60°.

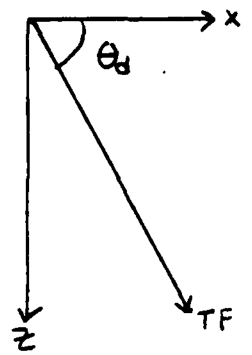


Figure 4.1 Total Field Diagram

The coher-nce between two signals a(t) and b(t) is

$$\text{coherence} = \frac{a(t) \circ b(t)}{\sqrt{a(t) \circ a(t)}\ \sqrt{b(t) \circ b(t)}} = \frac{A(F)B^*(F)}{\sqrt{A(F)A^*(F)}\ \sqrt{B(F)B^*(F)}}$$

where '$\circ$' indicates the correlation separation, '*' indicates

the complex conjugate is taken and $A(F)$ and $B(F)$ are the Fourier transforms of $a(t)$ and $b(t)$, respectively.

In the program, a Fourier transform of the data into frequency space was performed and an average of 20 blocks of data (128 seconds per block) was taken to obtain the final coherence values.

V. TESTING OF PCM SYSTEM AND SOFTWARE

In order to ensure that the PCM system and VOLTR program faithfully reproduced the input signals, sinusoidal, triangular and square waves were input to the PCM encoder by a Wavetek signal generator, as shown in Figure 5.1, and the PCM signal recorded on analog tape. The signal generator output was also monitored by a chart recorder and voltmeter. The analog tape was then decoded and voltage vs time plots were generated by the VOLTR program.

Table 5.1 shows the relationship between the amplitude of the signal generator output and the amplitude of the VOLTR plots (Figure 5.2) at various frequencies for the sinusoidal signal.

As can be seen from Table 5.1, the error between the chart record and the computer plot is less than two percent. Similar results were obtained for the triangular and square wave on all three channels.

Extensive testing of the Mass Storage program, and the digital filter algorithm employed in the VODIG program, is documented in References 6 and 7, respectively.

The program COHER was tested by analyzing a section of data against itself. Data from a computer tape was read into the mass storage system by the Mass Storage program. The same section of data was read from the tape by

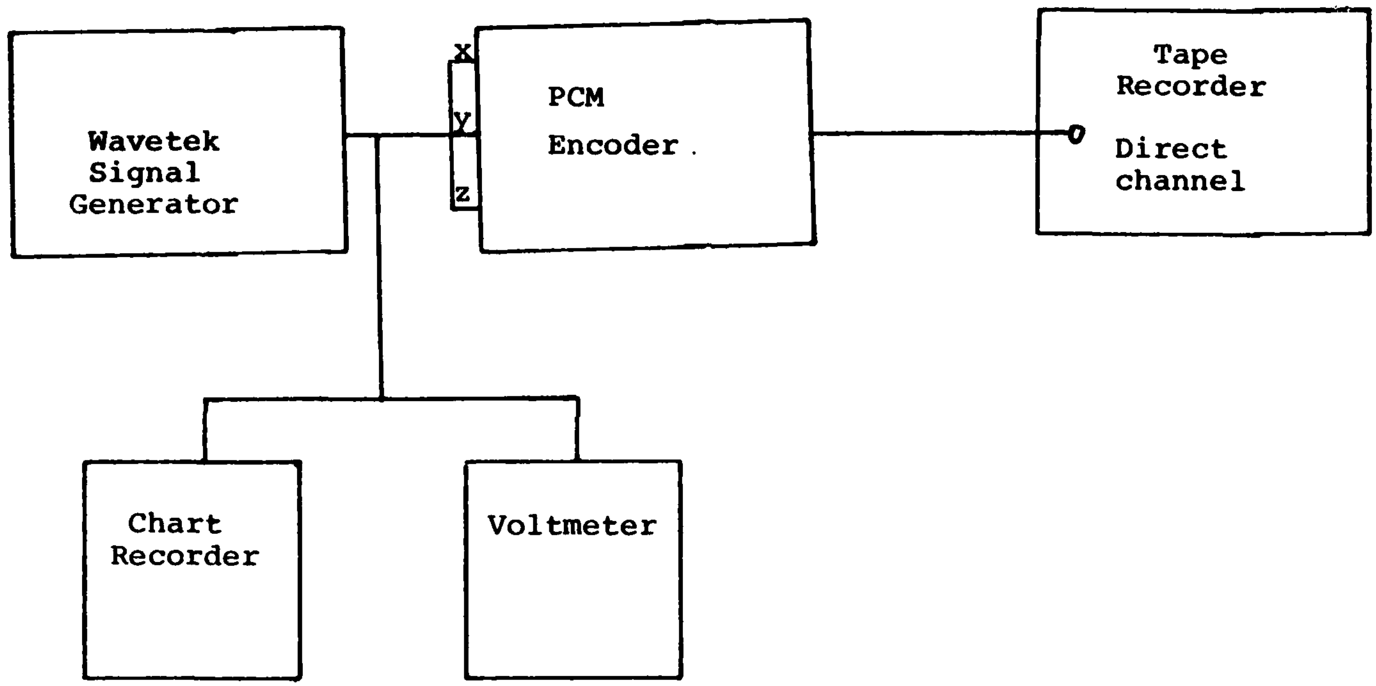


Figure 5.1 Block Diagram of Test System.

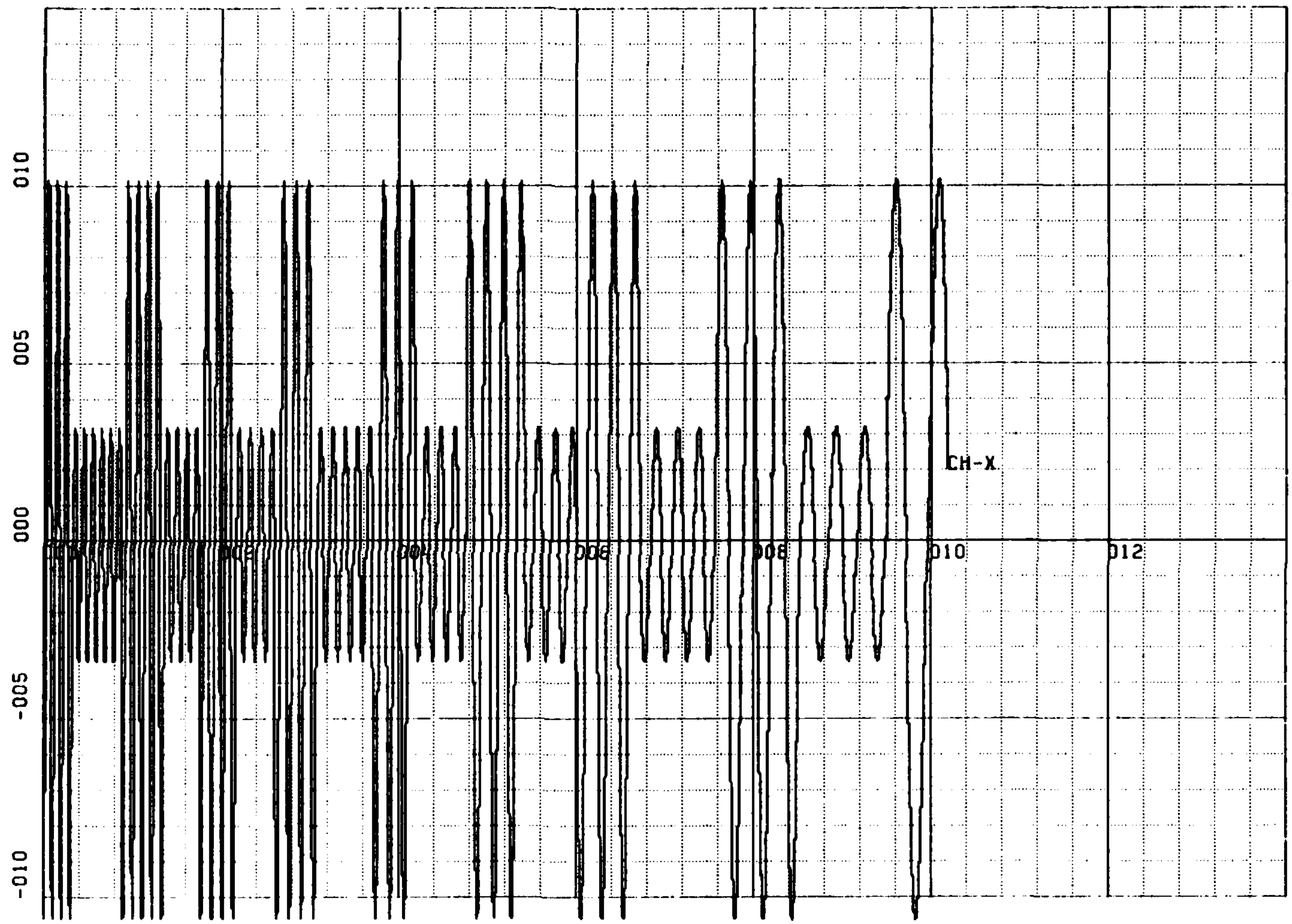


Figure 5.2 Test Voltage, Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

TABLE 5.1

MEASURED AND COMPUTER GENERATED VOLTAGE VALUES

Freq (Hz)	Chart Record (volts)		Computer Plot volts		Error %	
	Large Amplitude Oscillations	Small Amplitude Oscillations	Large Amplitude Oscillations	Small Amplitude Oscillations	Large	Small
0.10	2.10 ± .01	0.67 ± .01	2.08 ± .01	0.66 ± .01	1.0	1.5
0.09	2.09	0.67	2.08	0.66	0.5	1.5
0.08	2.09	0.67	2.08	0.66	0.5	1.5
0.07	2.09	0.67	2.08	0.66	0.5	1.5
0.06	2.09	0.67	2.08	0.66	0.5	1.5
0.05	2.10	0.67	2.08	0.66	1.0	1.5
0.04	2.10	0.67	2.08	0.66	1.0	1.5
0.03	2.10	0.67	2.08	0.66	1.0	1.5
0.02	2.11	0.67	2.08	0.66	1.4	1.5
0.01	2.11	0.67	2.08	0.66	1.4	1.5

the COHER program and analyzed with the data recalled from mass storage. The COHER program generated a coherence vs frequency of 1 as expected (Figure 5.3).

Reference 8 mentioned the presence of "cross-talk" between the channels of the PCM encoder. This was noticed on computer generated plots on a channel whose input jack was left open while making measurements at a field site. To test for "cross-talk", a signal from the Wavetek signal generator was fed into all three channels of the PCM encoder, as in Figure 5.1. One of the channels was disconnected from the Wavetek and the input jack left open. Then the input jack was grounded, and then finally the Wavetek signal was reconnected. Figure 5.4 is a rough voltage vs time plot for the sequence. It can be seen that while the input jack was open a signal did appear on the channel but disappeared while the input jack was grounded. The "cross-talk" mentioned in Reference 8 was actually the open input jack acting as a "pickup" antenna.

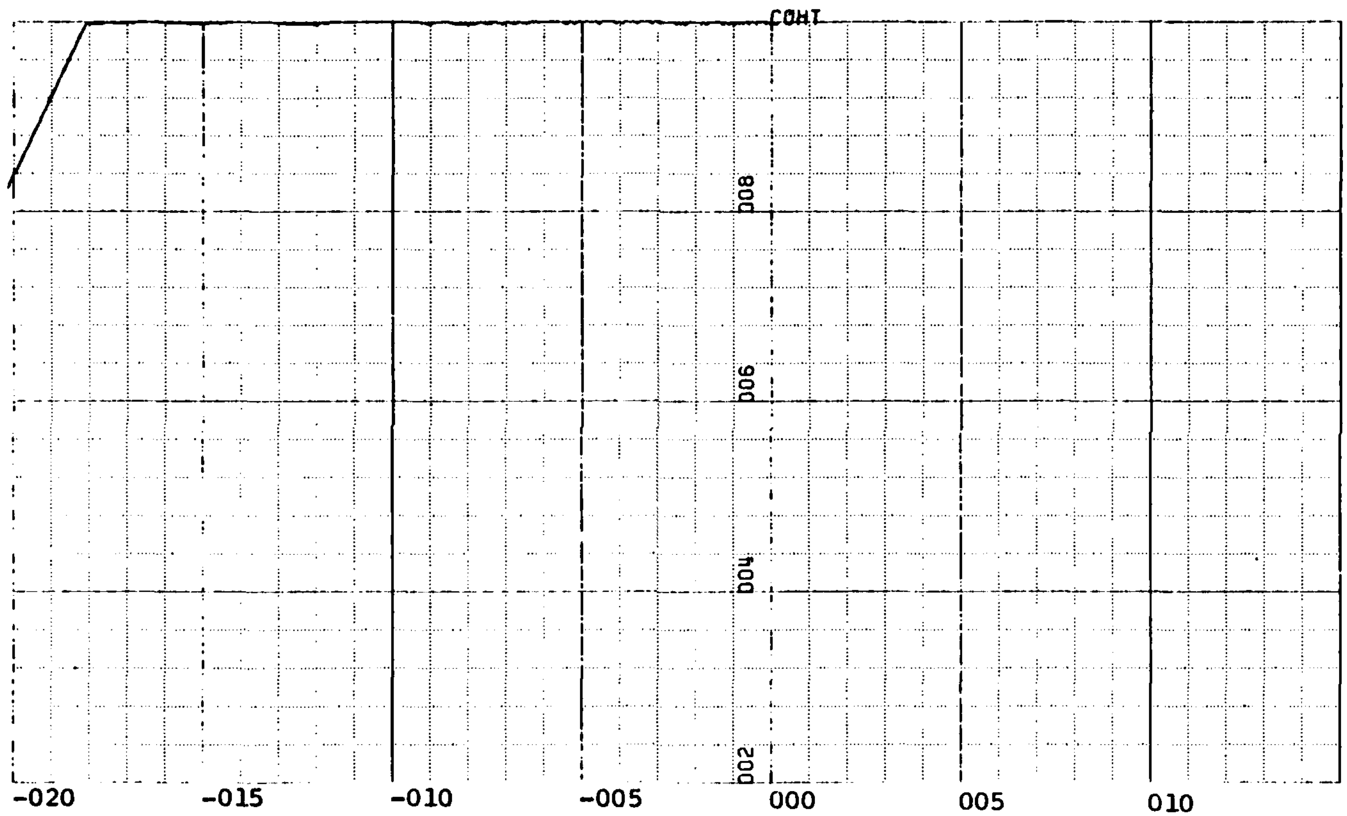


Figure 5.3 Coherence Test, Coherence (0.2 units/inch) vs Log Frequency (0.5 log Hz/inch).

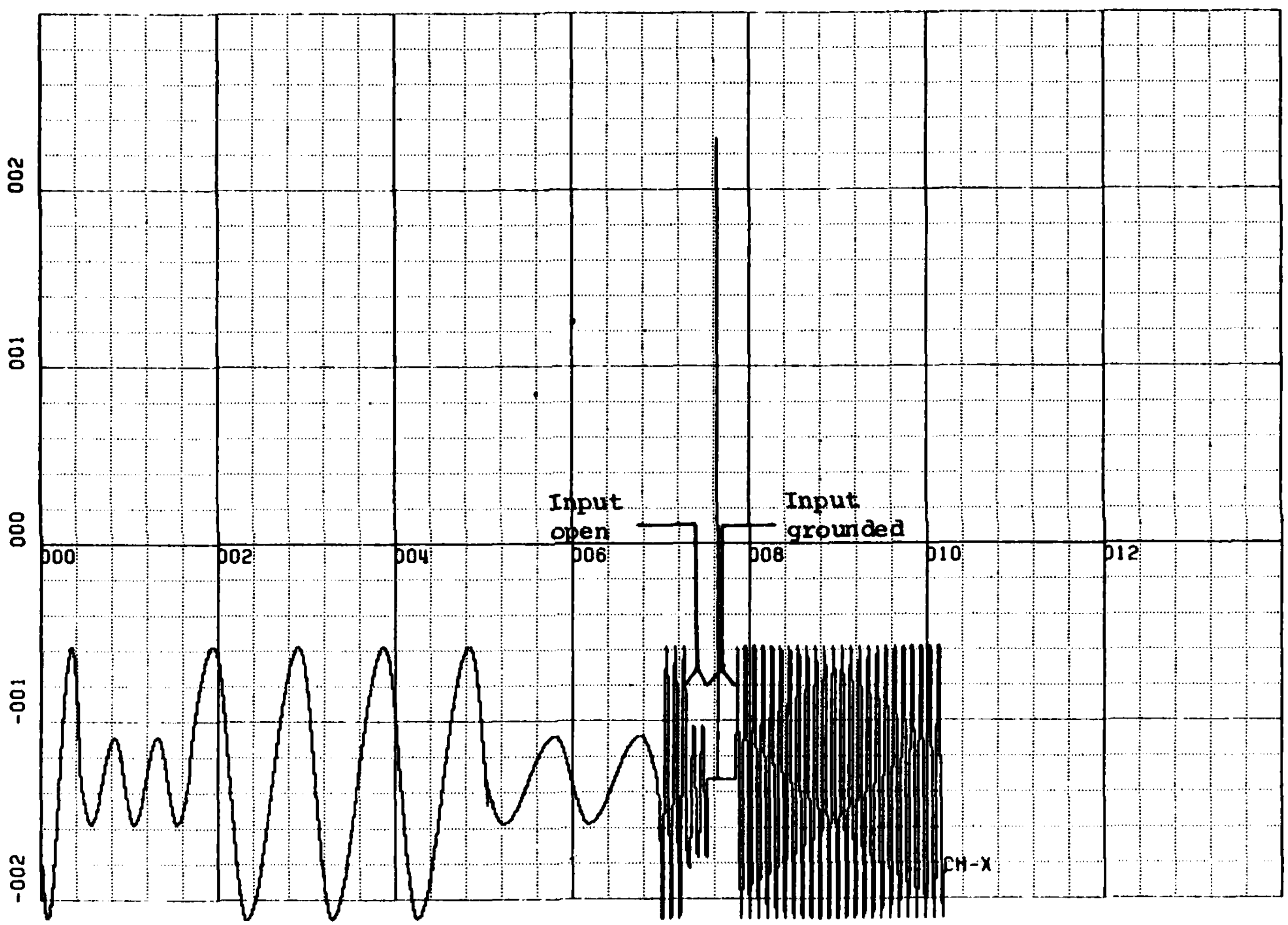


Figure 5.4 Test Voltage, Voltage (1 volts/inch) vs Time (200 seconds/inch).

VI. EXPERIMENTAL RESULTS

Data was taken on 4 August 1983 between 1300 and 1845 local time. Beginning and ending the recording of the analog tapes was coordinated between the two sites over PRC-77 radios. Since it proved difficult to communicate between the two sites directly (because of intervening hills), a person using a radio with a large whip antenna at the Naval Postgraduate School directed the simultaneous starting and ending of data recording at the two sites.

On the voltage and magnetic field plots, the units labeled on the vertical scale are arbitrary and only the peak-to-peak variations should be considered.

A. ROUGH VOLTAGE PLOTS

Figures 6.1 - 6.6 show the rough voltage plots for the La Mesa Village site. These signals are totally obscured by 60 Hz noise. Figures 6.7 - 6.12 show the Chew's Ridge rough voltage plots. Here the 60 Hz noise is a site as remote as Chew's Ridge (to escape the 60 Hz power grid) is thus justified.

B. FILTERED VOLTAGE PLOTS

Figures 6.13 - 6.30 show typical filtered voltage vs time plots for both sites. Visual inspection failed to

reveal the presence of any large amplitude micropulsations or of any clear one-to-one correspondence in simultaneous sections of data.

C. MAGNETIC FIELD PLOTS

Figures 6.31 - 6.45 show typical magnetic field vs time plots for both sites. Magnetic field variations at the La Mesa site are approximately one nanotesla; variations at the Chew's Ridge site are slightly greater, 2 - 4 nanotesla.

D. COHERENCE PLOTS

Figures 6.46 - 6.57 show coherence vs frequency plots for individual axes and for the total field. The coherence generally has values between 0.6 - 0.8 indicating a moderate degree of commonality in the geomagnetic variations at the two sites.

These coherence plots can be compared with coherence vs frequency plots generated from background geomagnetic variation data taken at the Naval Air Development Center in 1979. The separation between the NADC data collection sites was 24.8 km. Figures 6.58 - 6.60 show these plots. In general, the coherence values from the NADC data are less than the coherence values found in our measurements. However, the amplitudes of geomagnetic variations are

probably influenced by factors such as the state of the ionosphere and magnetosphere and the stage of the solar cycle.

The NADC data was averaged over a period of two hours while our data was averaged over a period of 40 minutes.

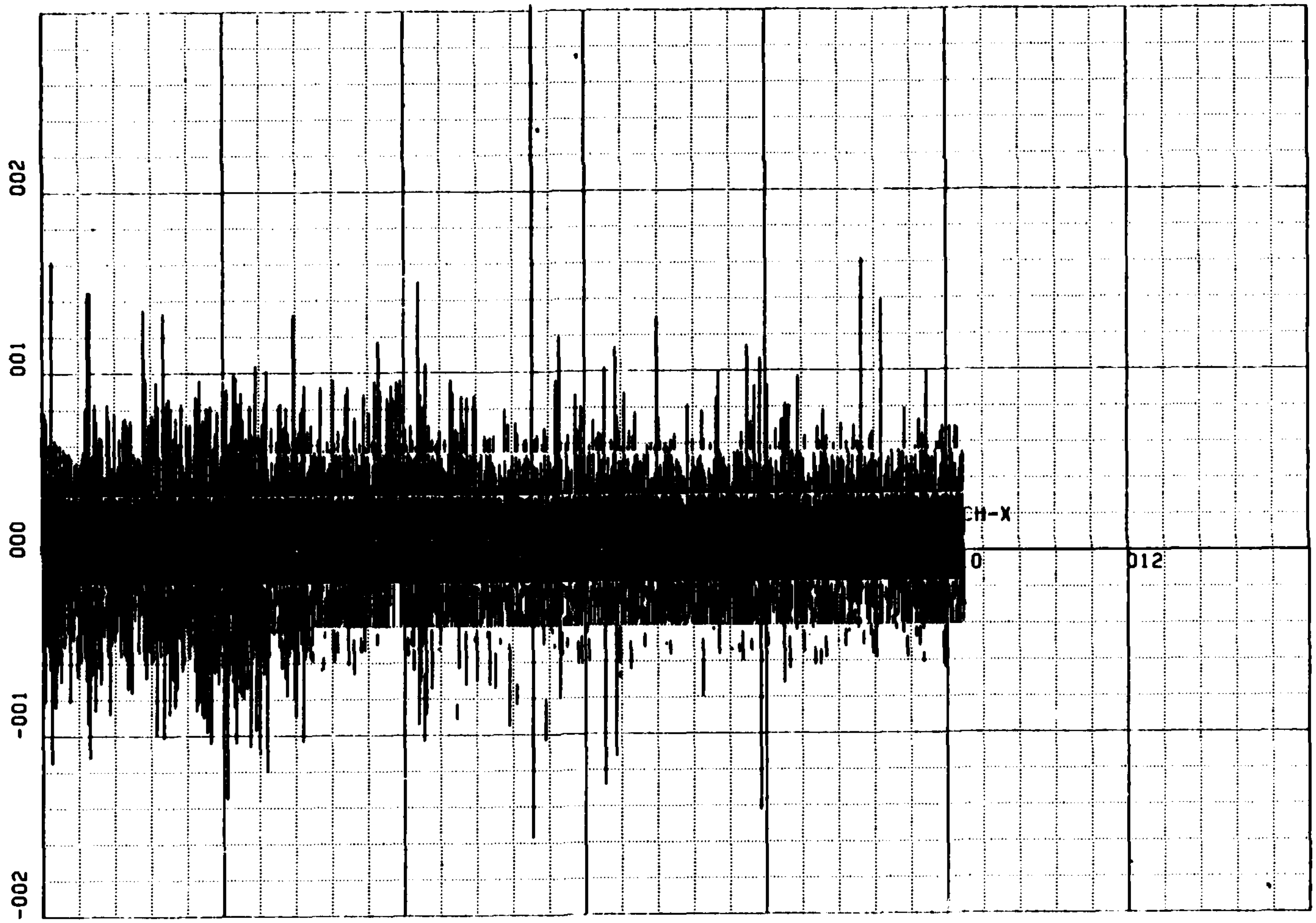


Figure 6.1 X Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

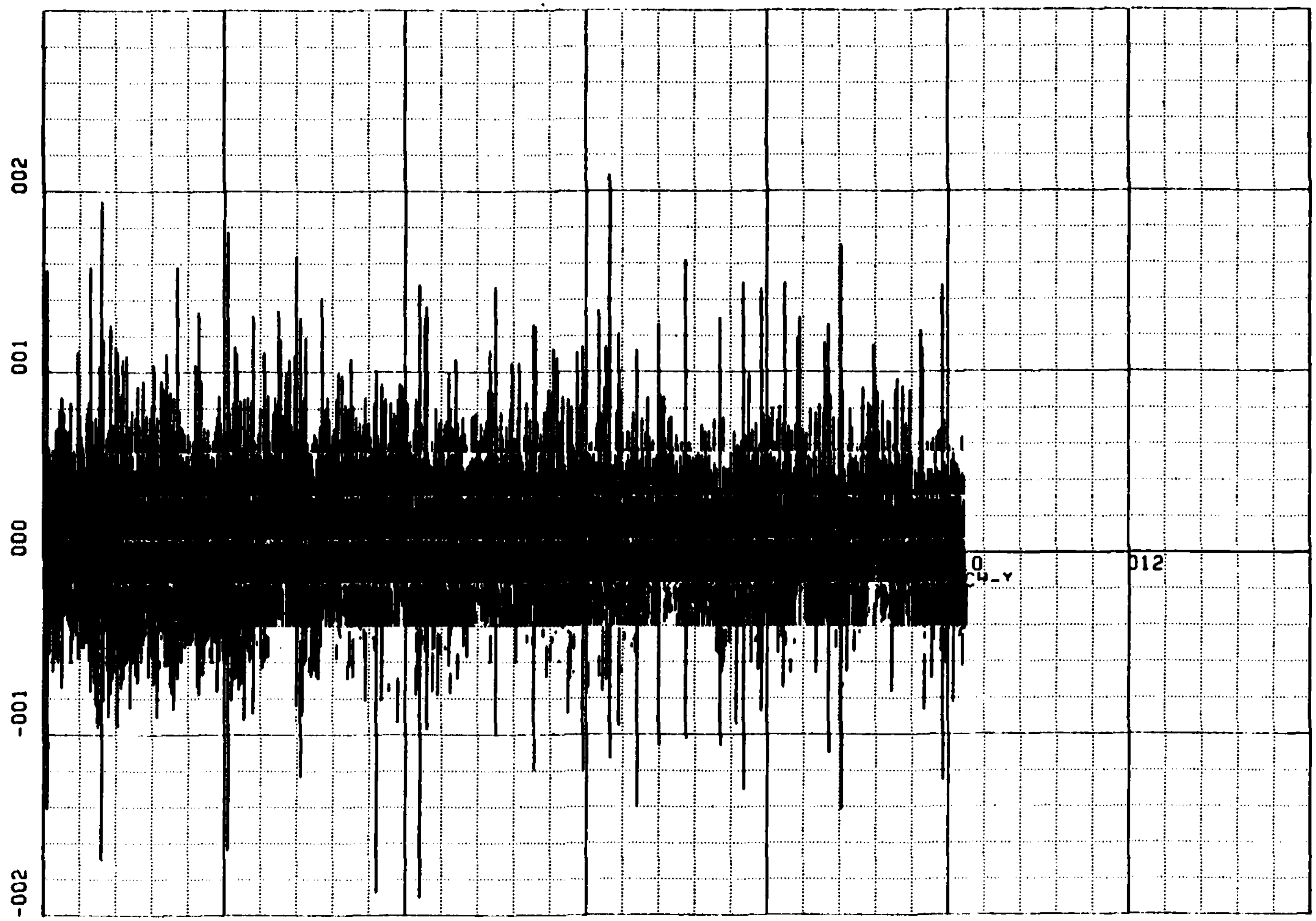


Figure 6.2 Y Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

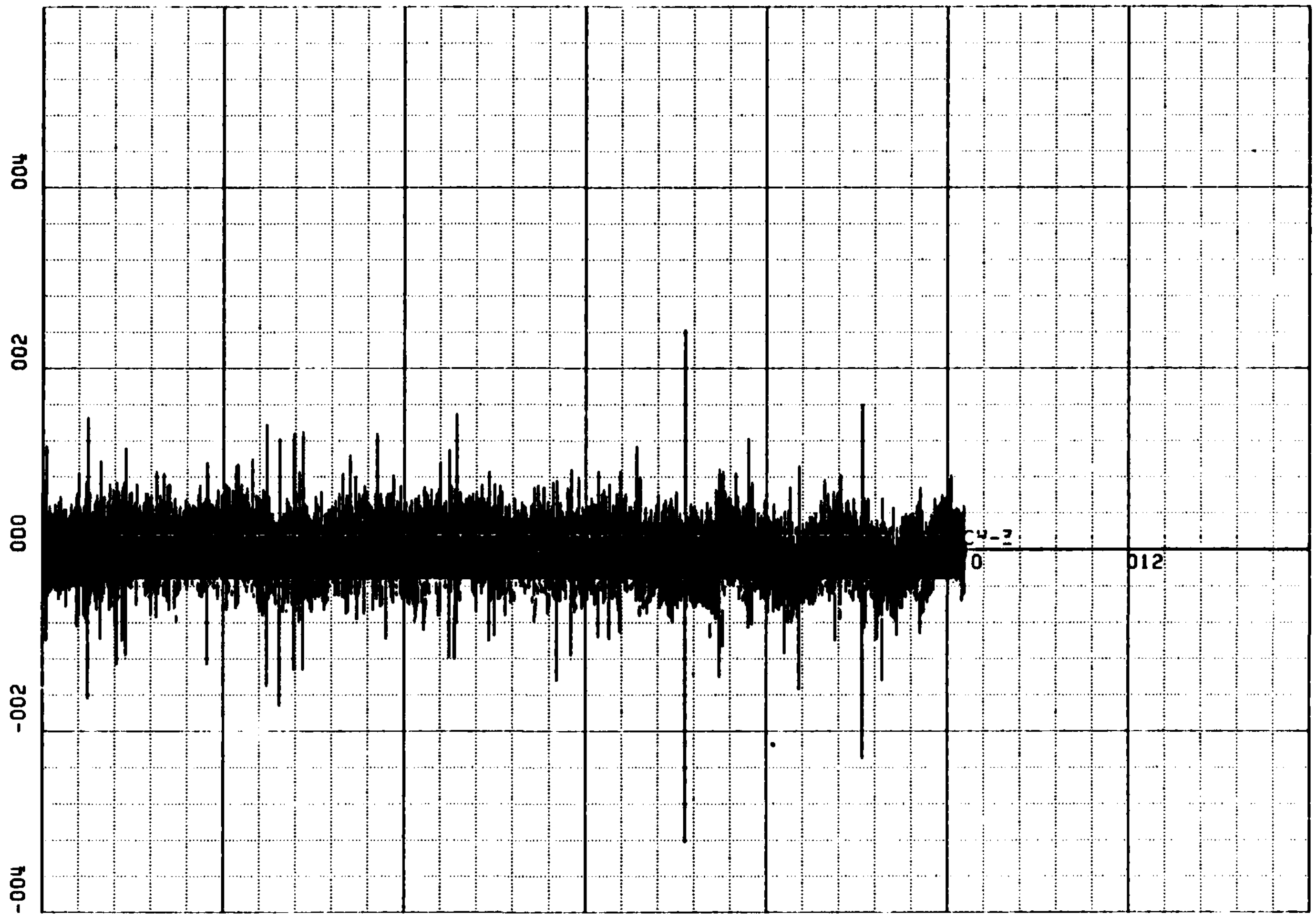


Figure 6.3 Z Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (2 volts/inch) vs Time (200 seconds/inch).

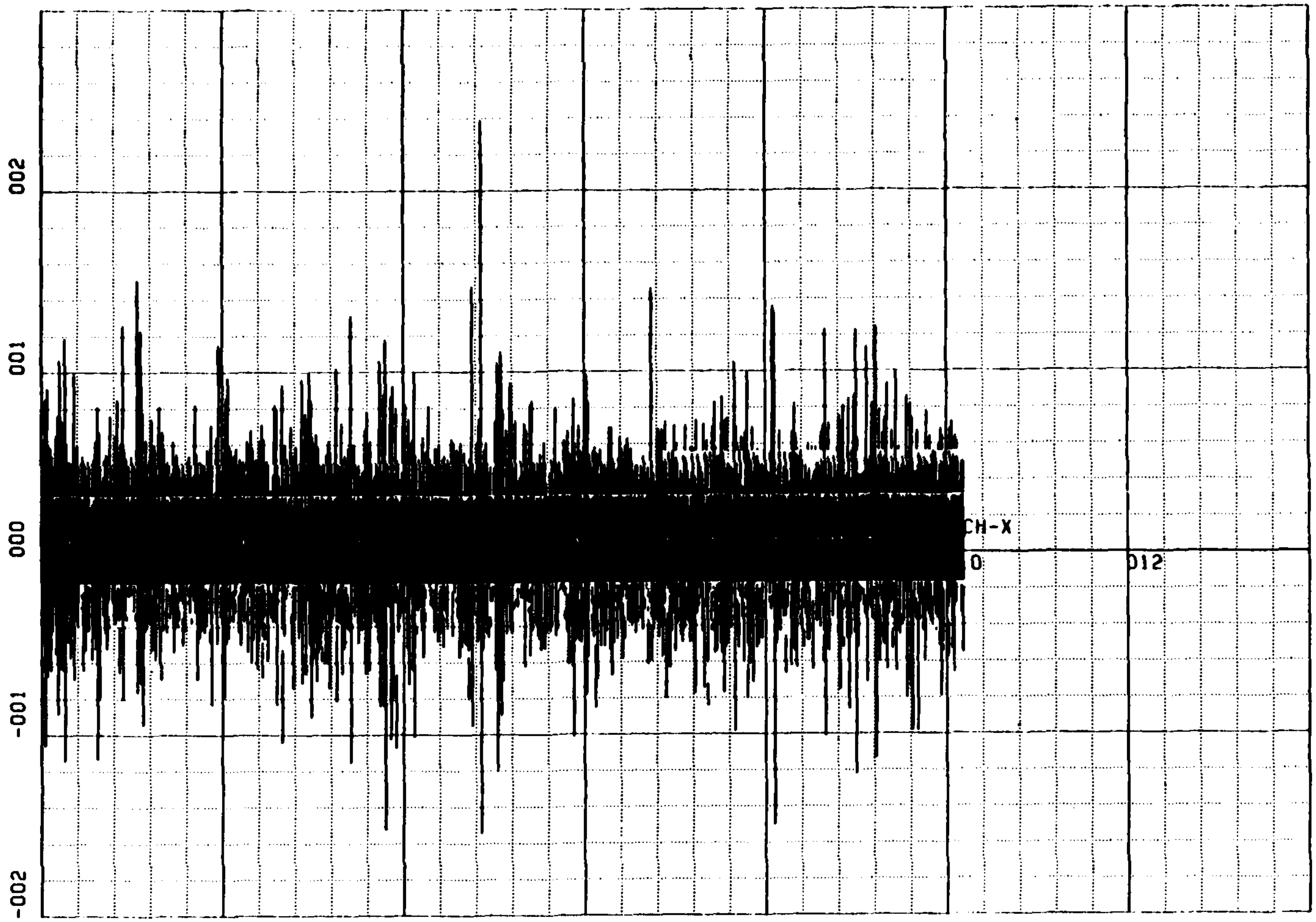


Figure 6.4 X Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

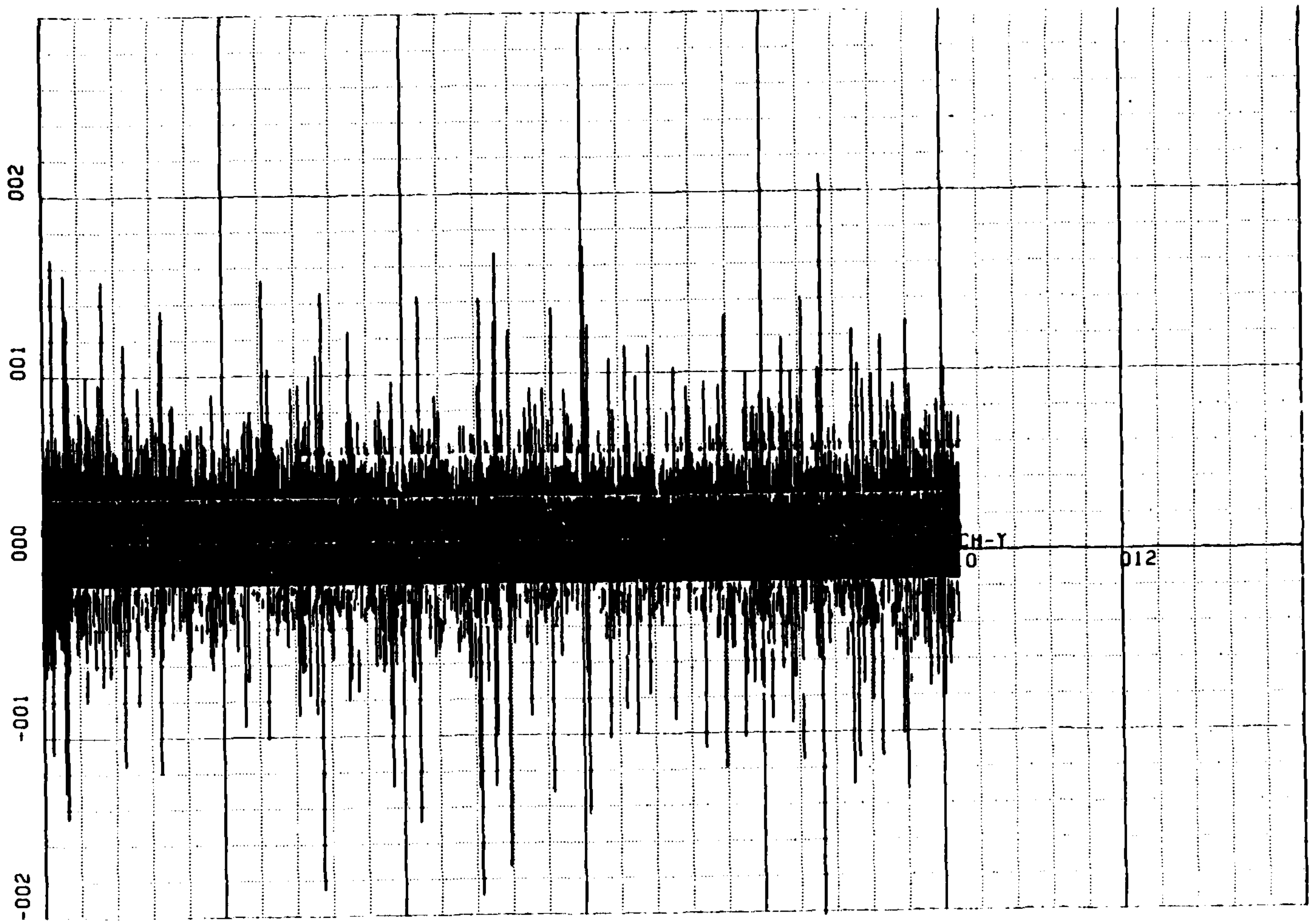


Figure 6.5 Y Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

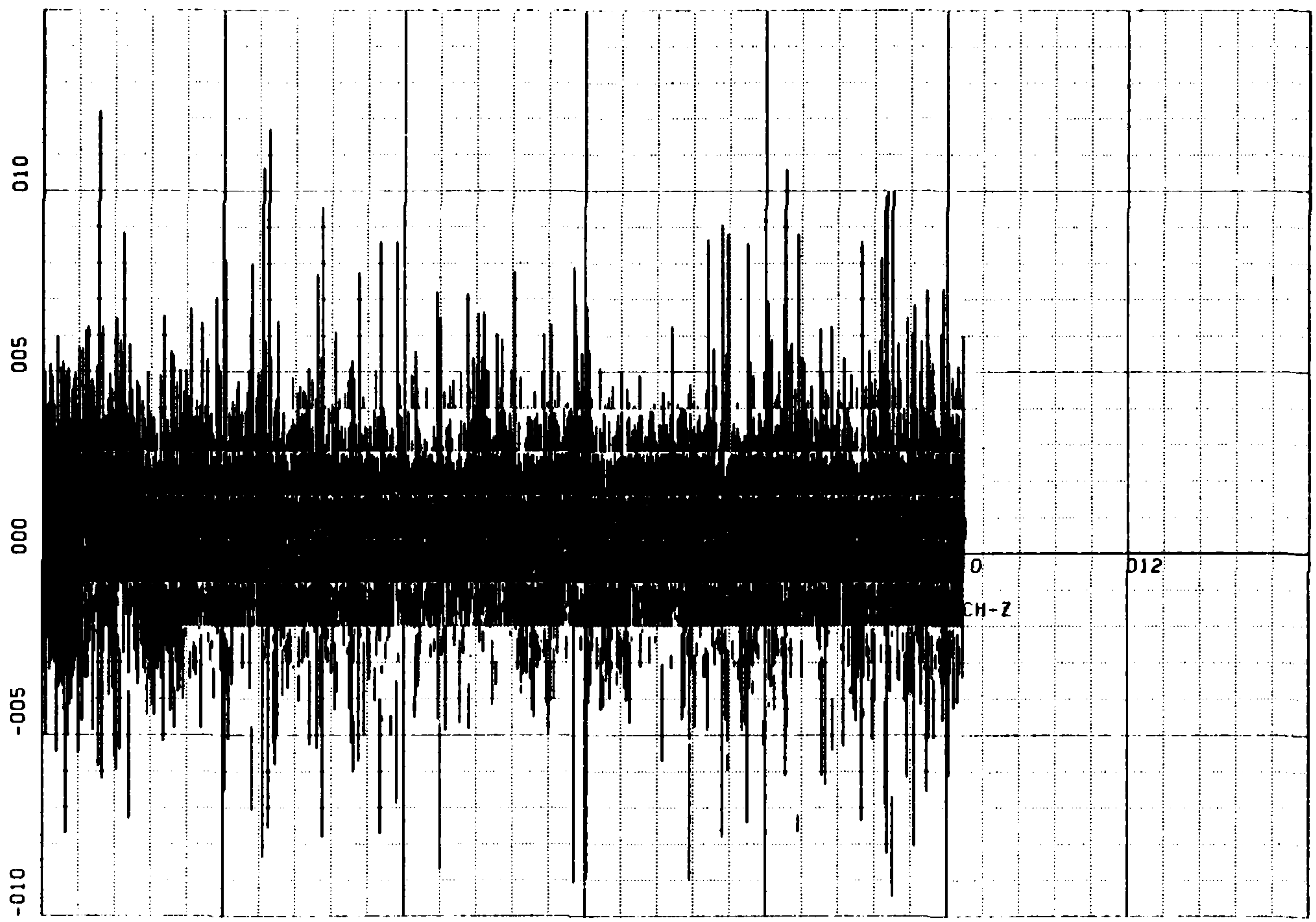


Figure 6.6 Z Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

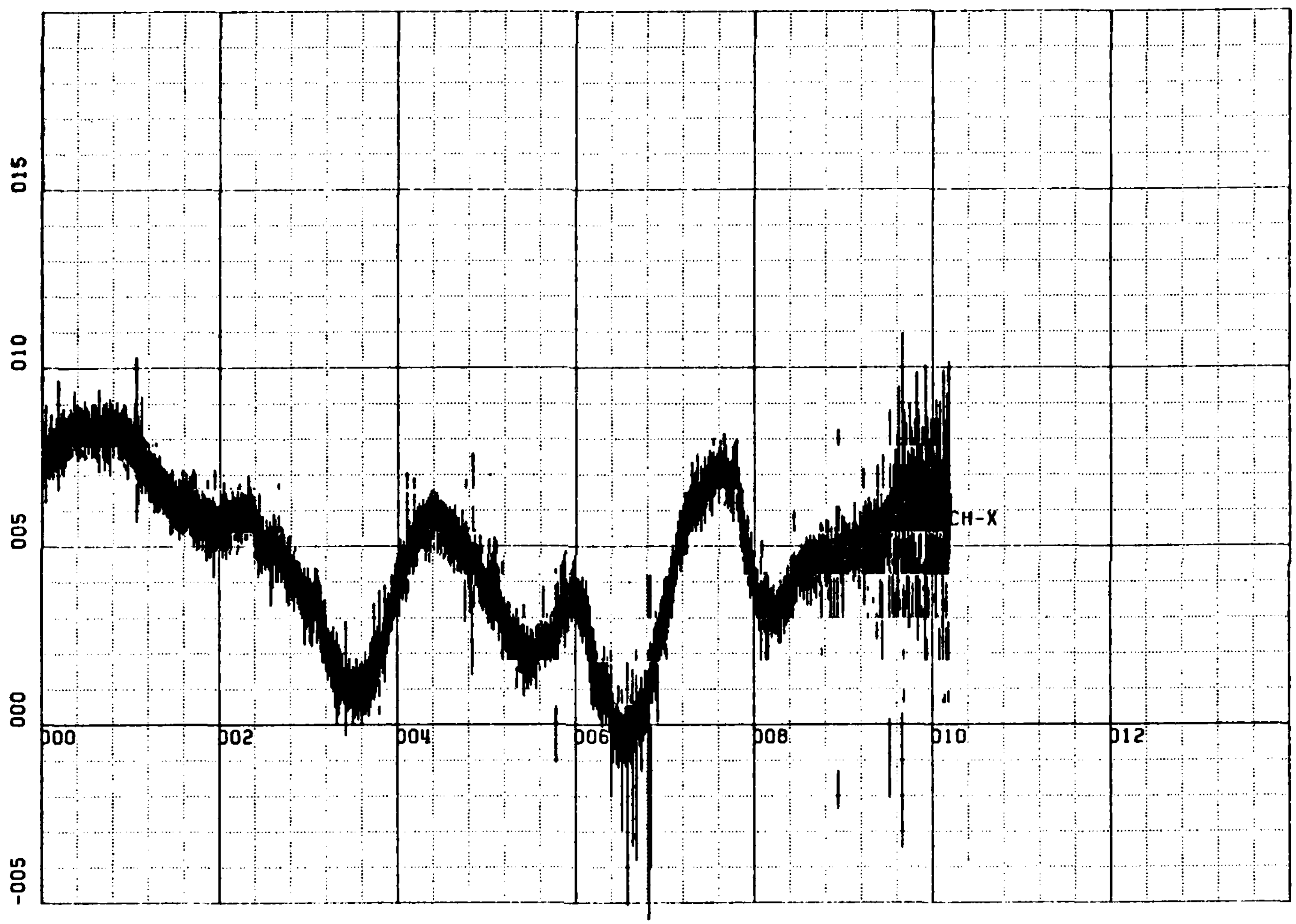


Figure 6.7 X Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

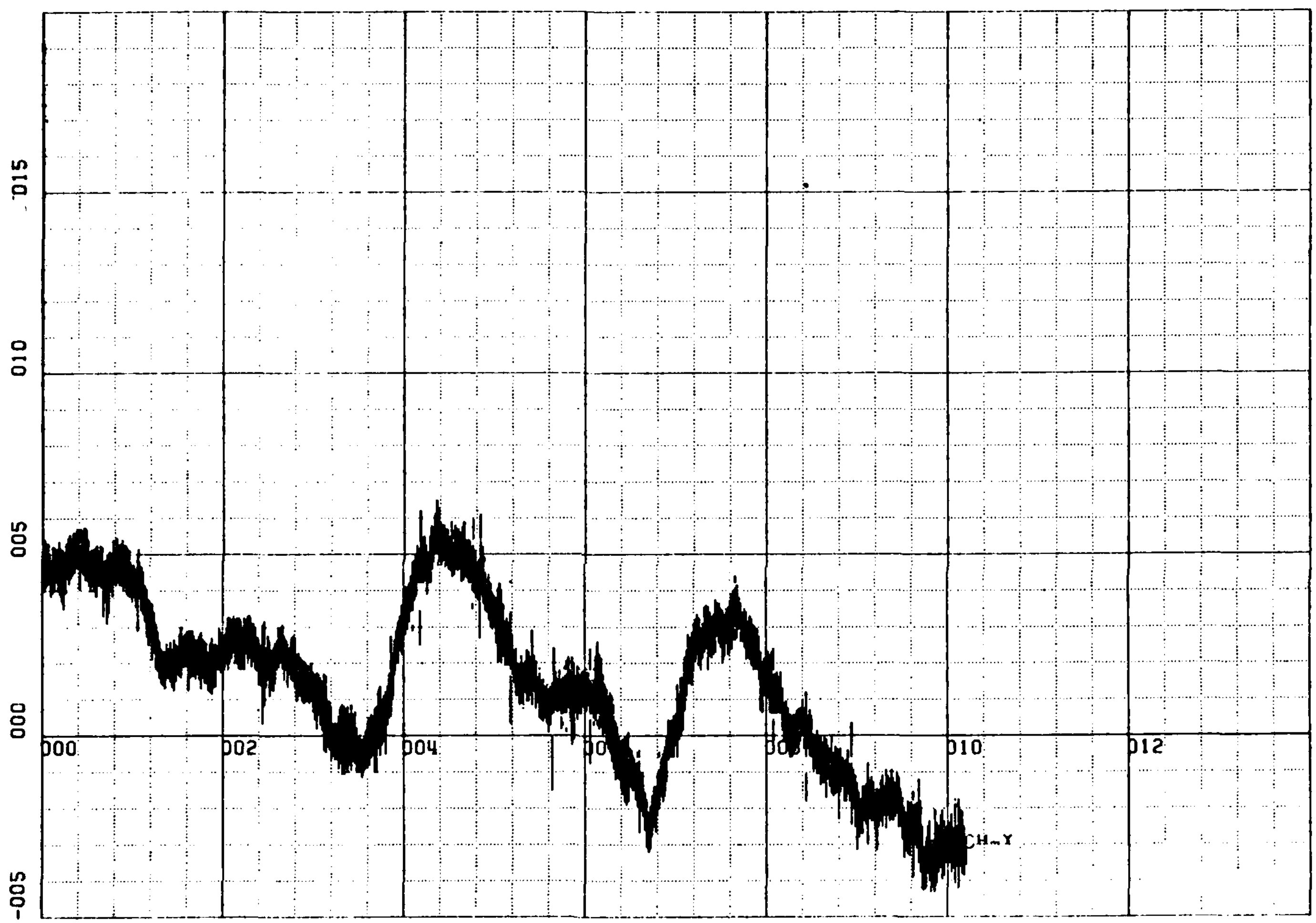


Figure 6.8 Y Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

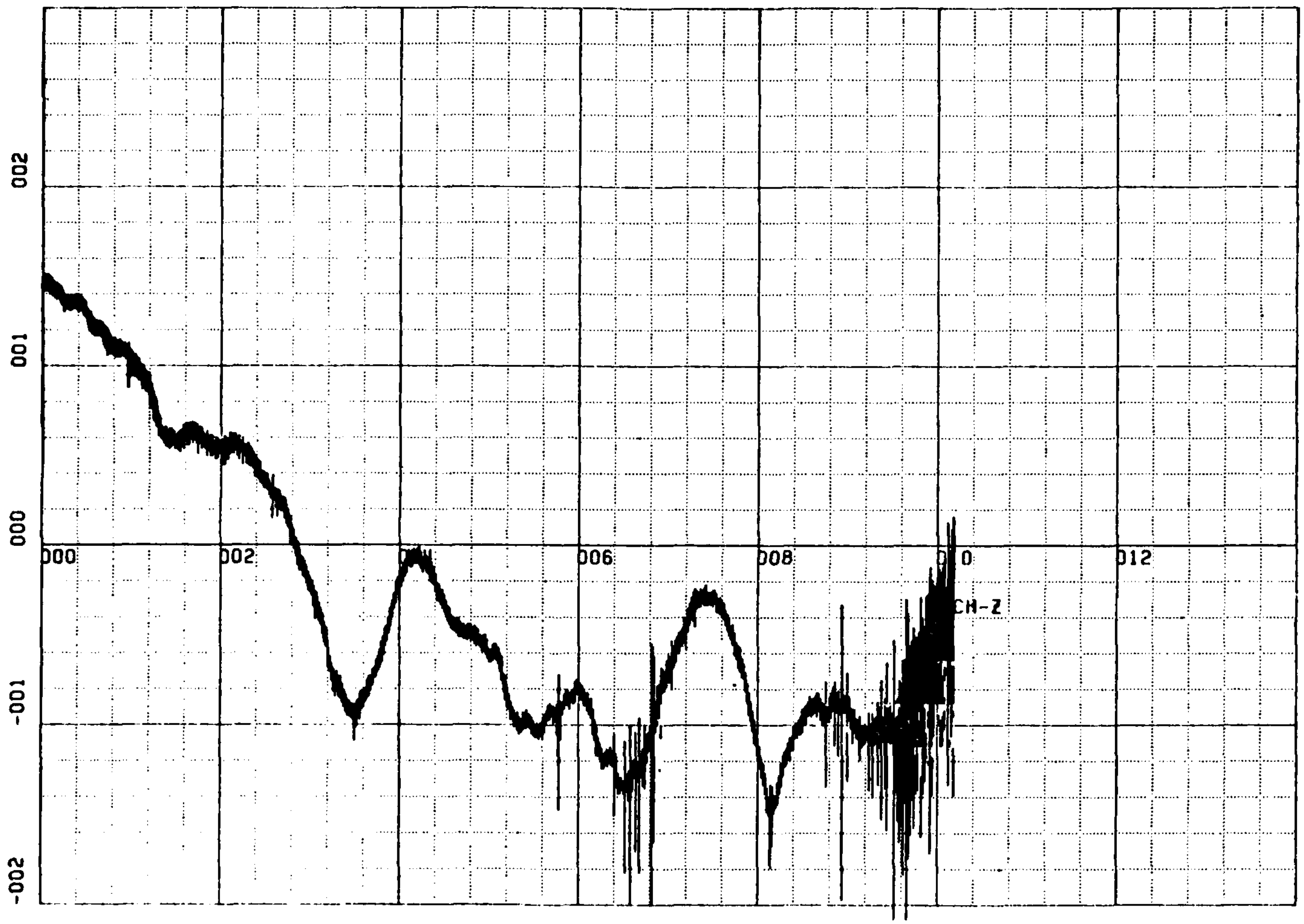


Figure 6.9 Z Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

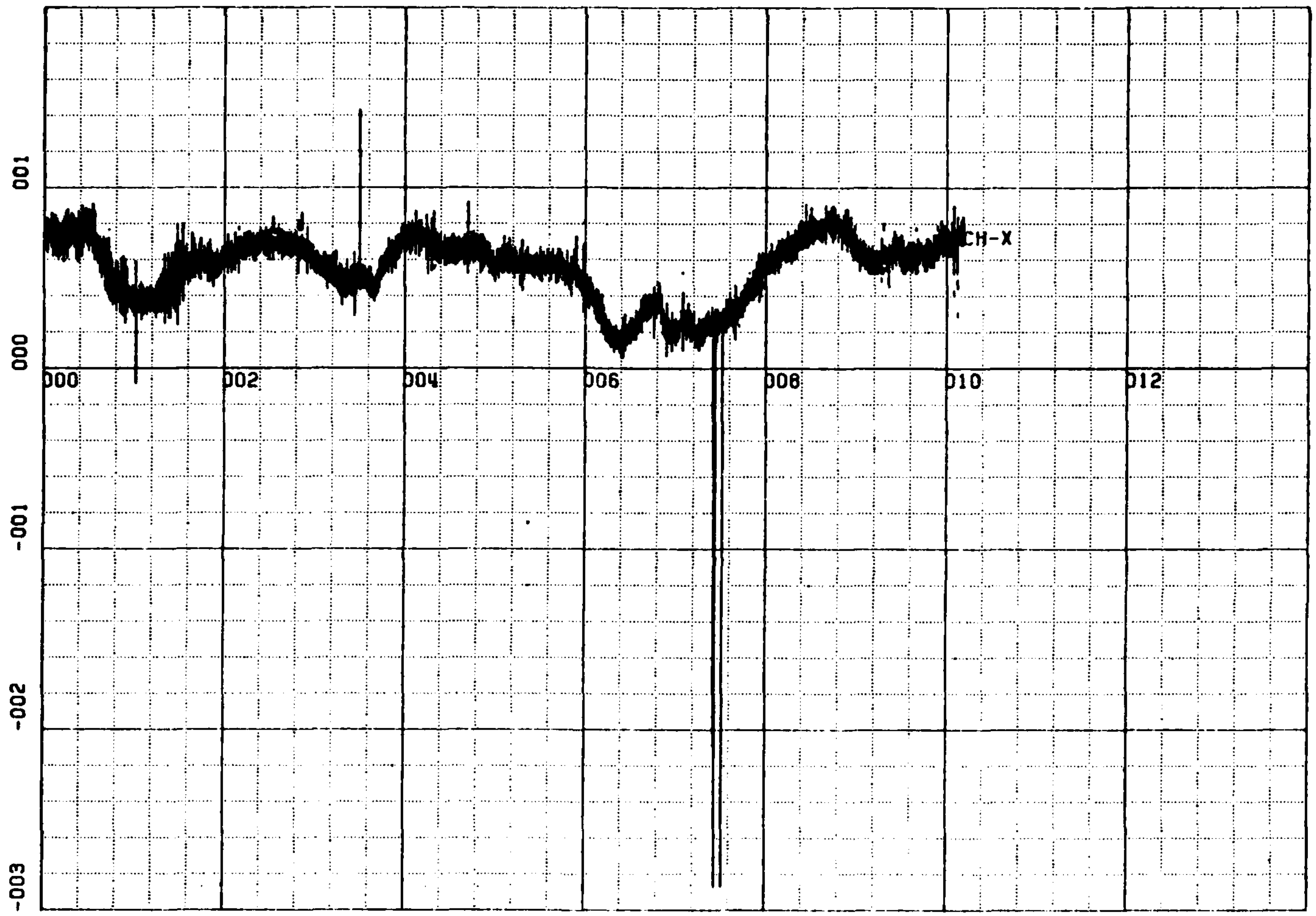


Figure 6.10 X Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

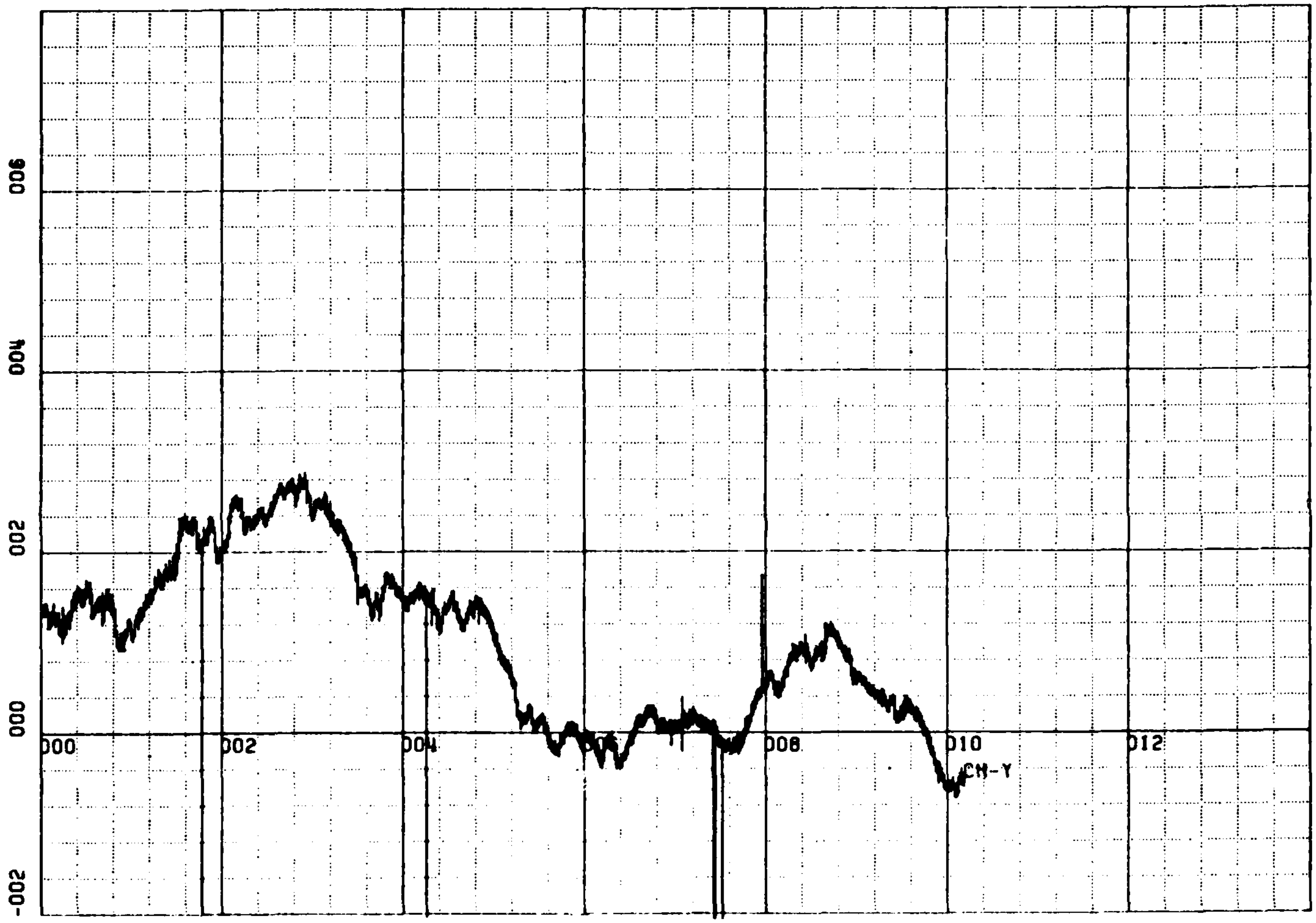


Figure 6.11 Y Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (2 volts/inch) vs Time (200 seconds/inch).

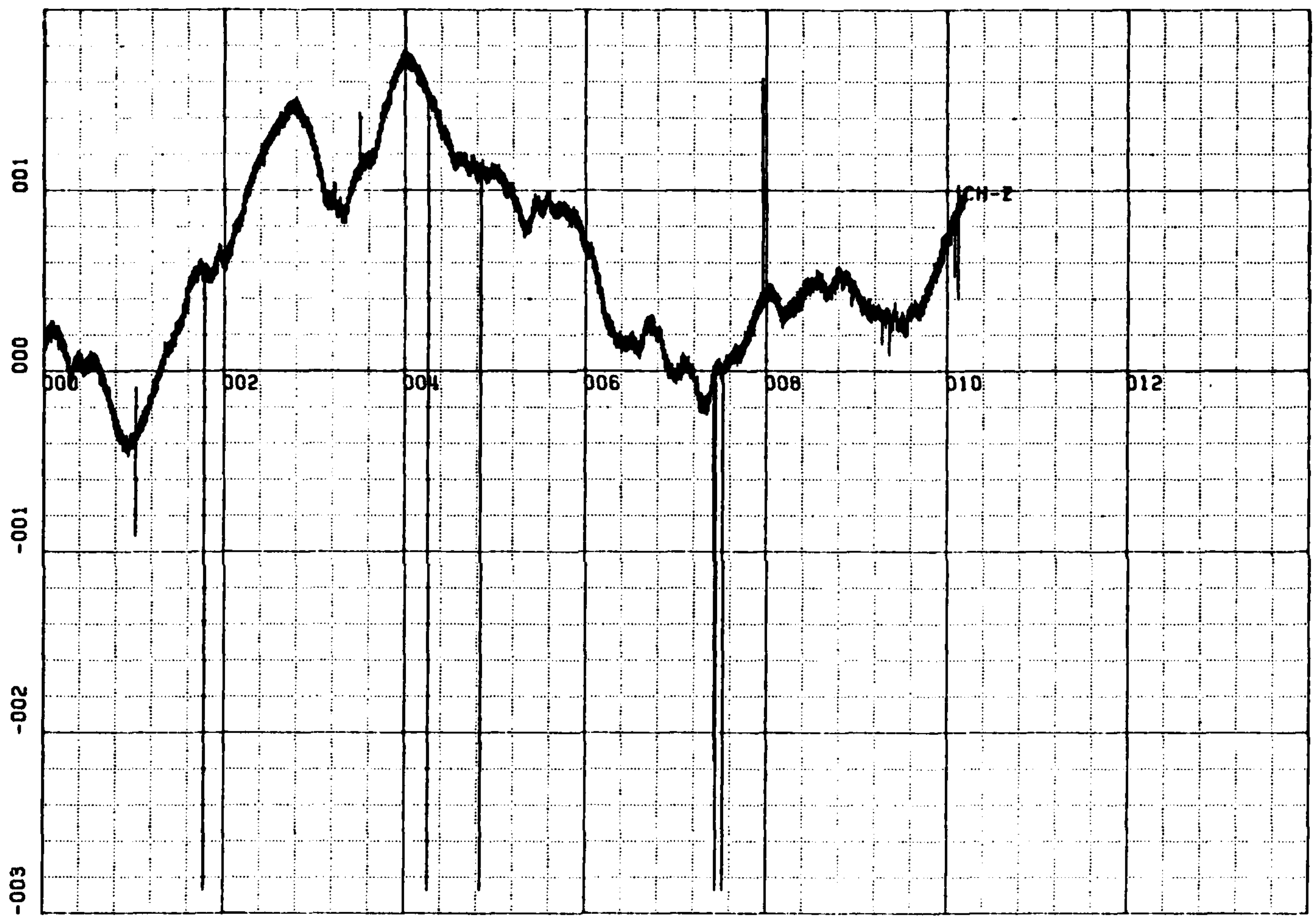


Figure 6.12 Z Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

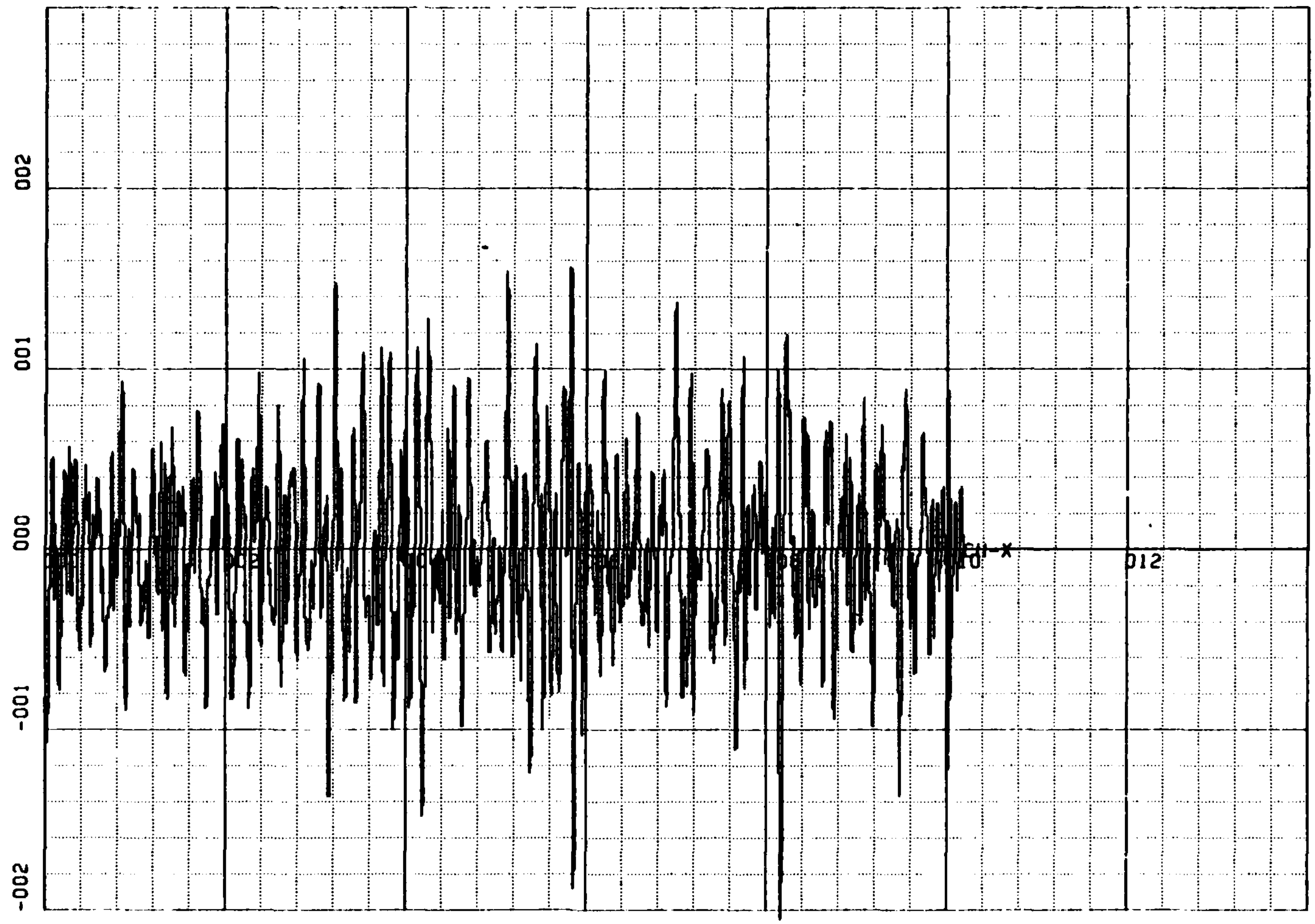


Figure 6.13 X Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

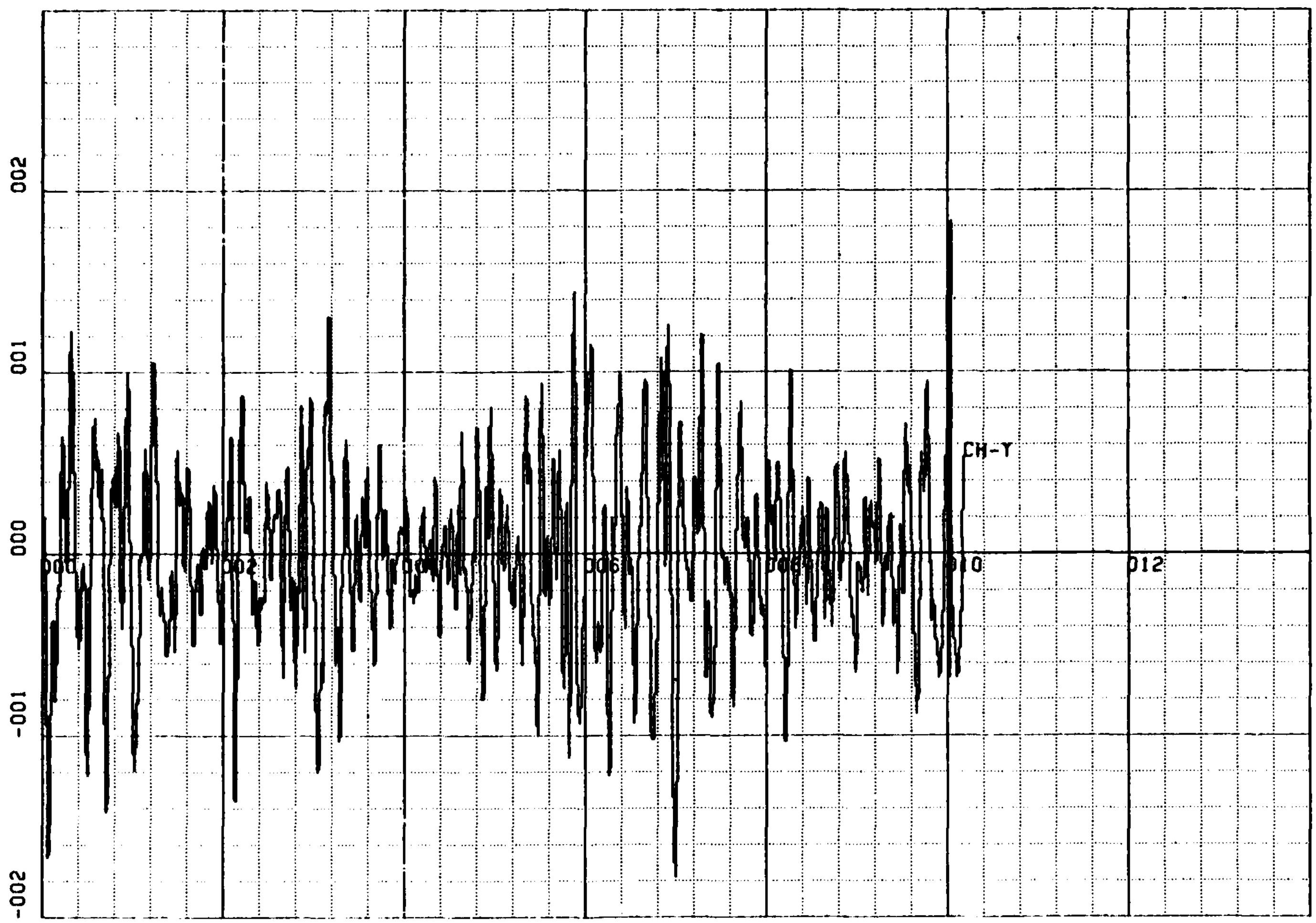


Figure 6.14 Y Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.01 volts/inch) vs Time (200 seconds/inch).

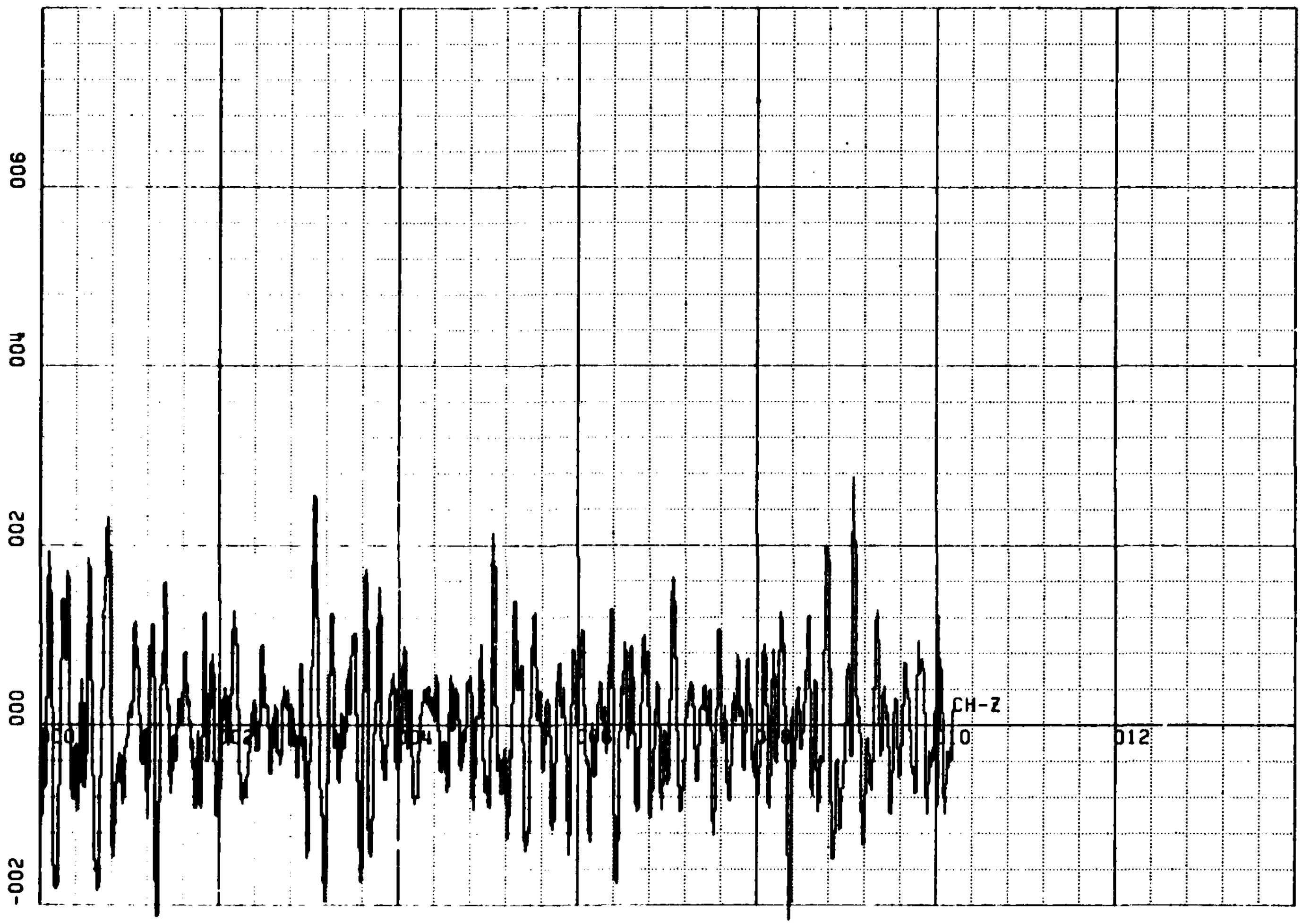


Figure 6.15 Z Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

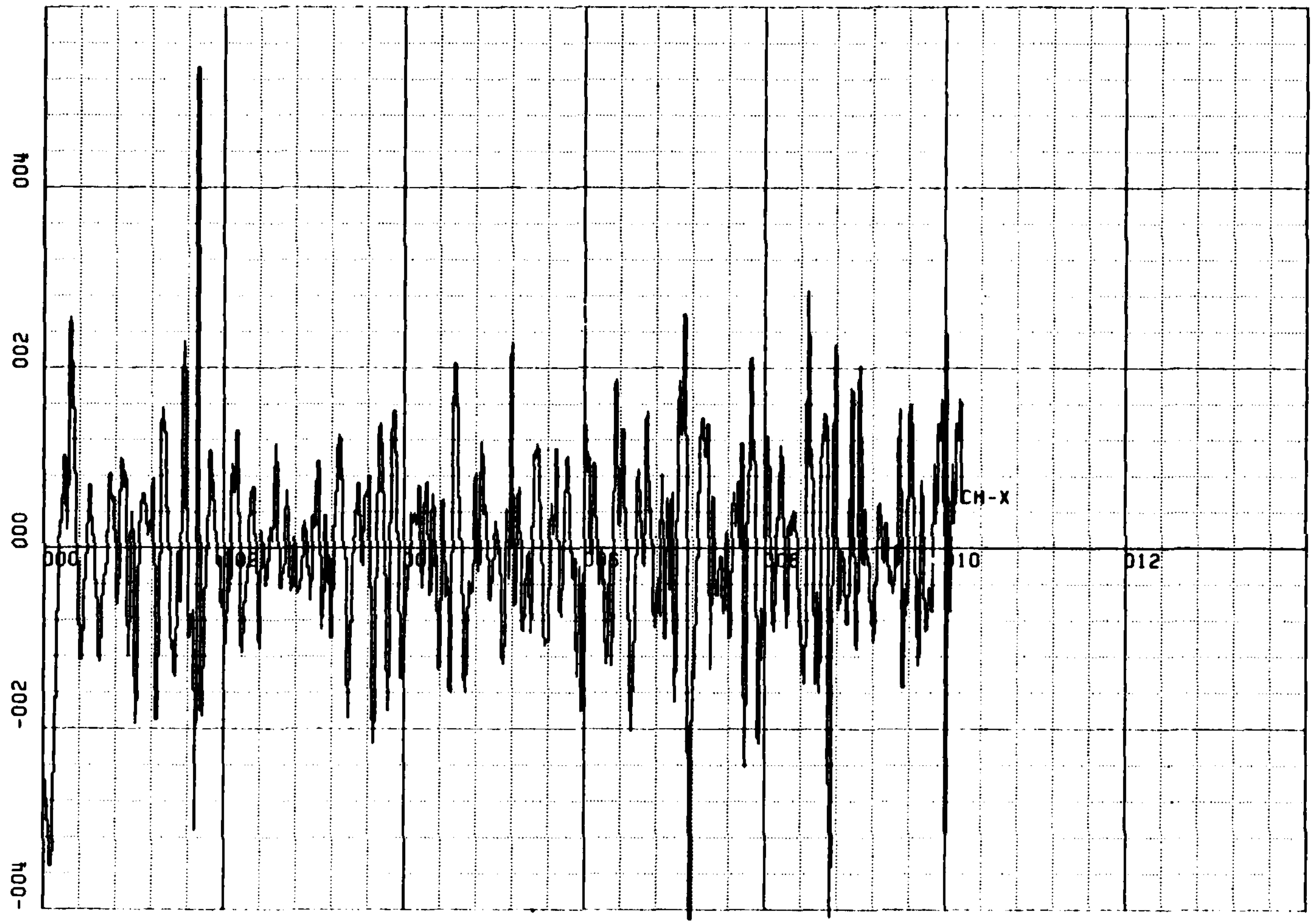


Figure 6.16 X Coil Voltage

Chew's Ridge, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

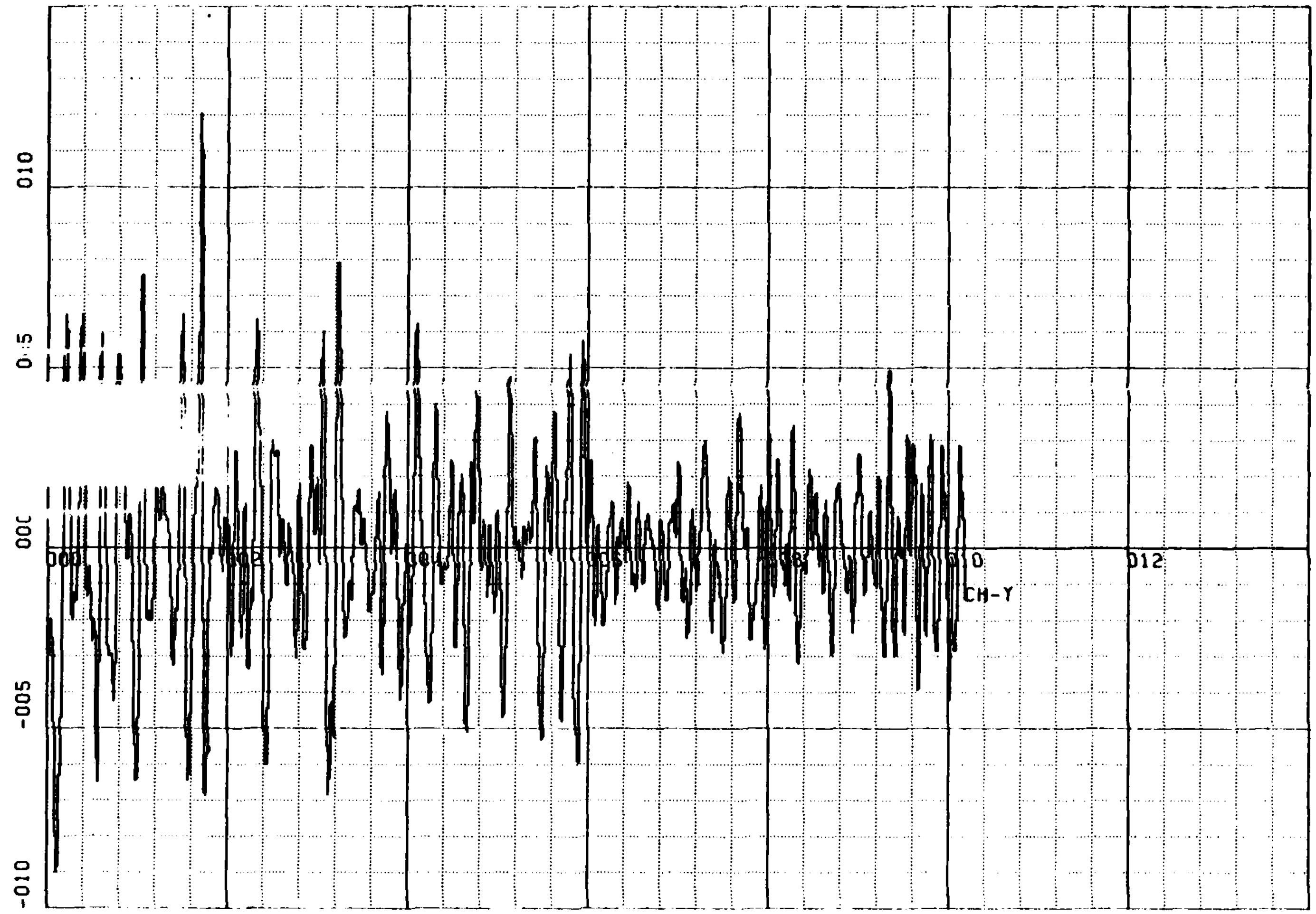


Figure 6.17 Y Coil Voltage

Chew's Ridge, 1610 - 1617 Local

Voltage (0.05 volts/inch) vs Time (200 seconds/inch).

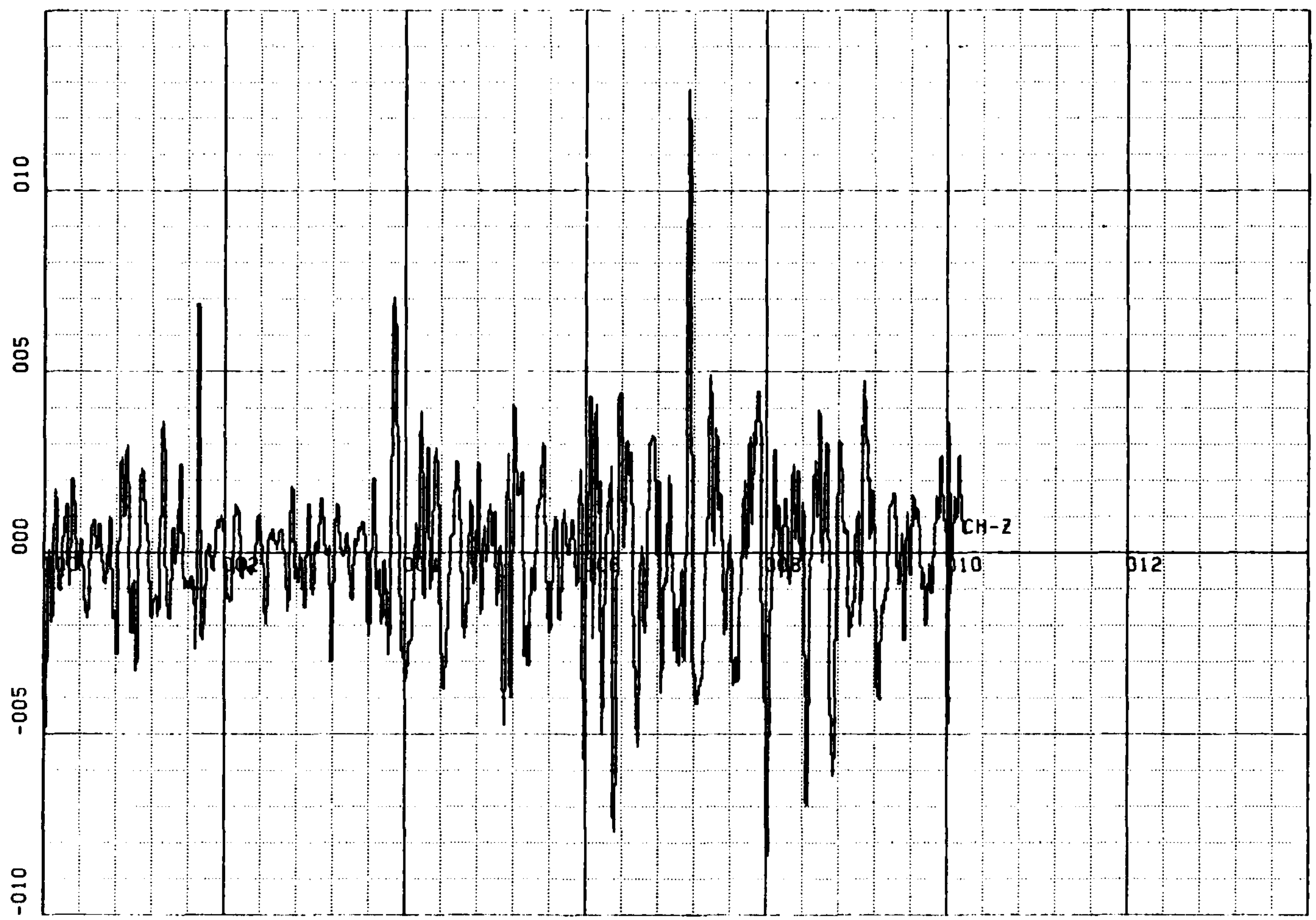


Figure 6.18 Z Coil Voltage

Chew's Ridge, 1610 - 1627 Local

Voltage (0.05 volts/inch) vs Time (200 seconds/inch).

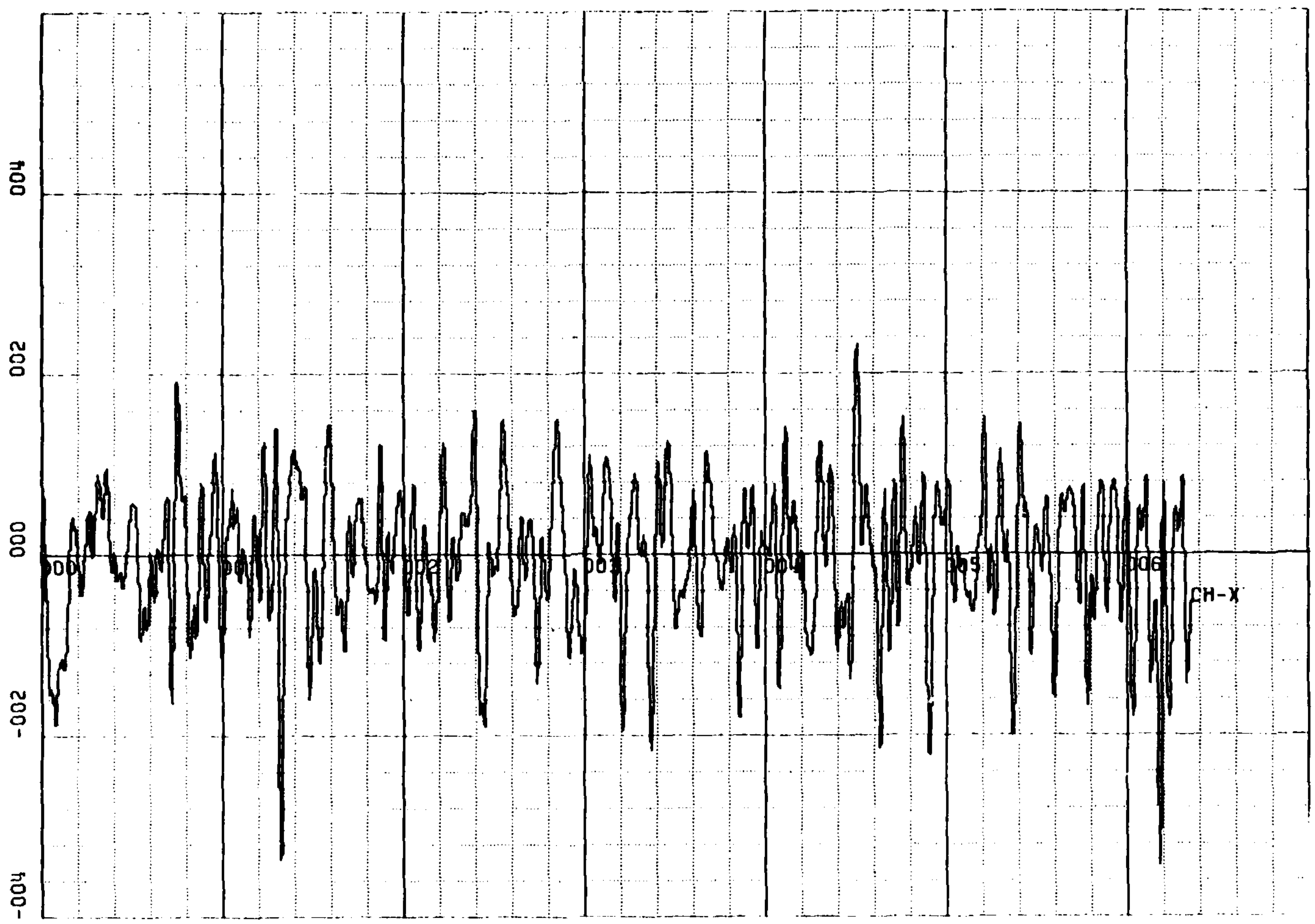


Figure 6.19 X Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

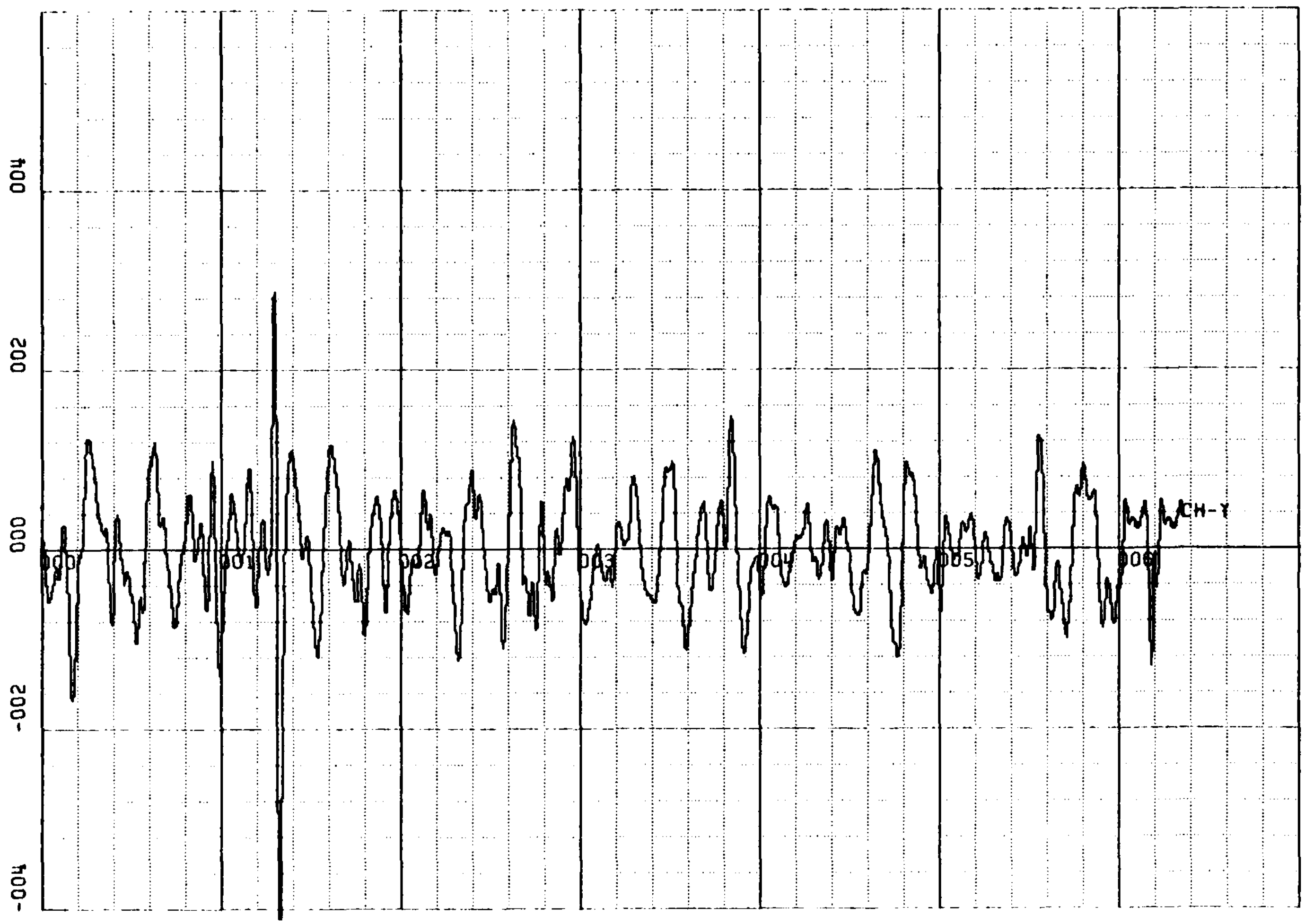


Figure 6.20 Y Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

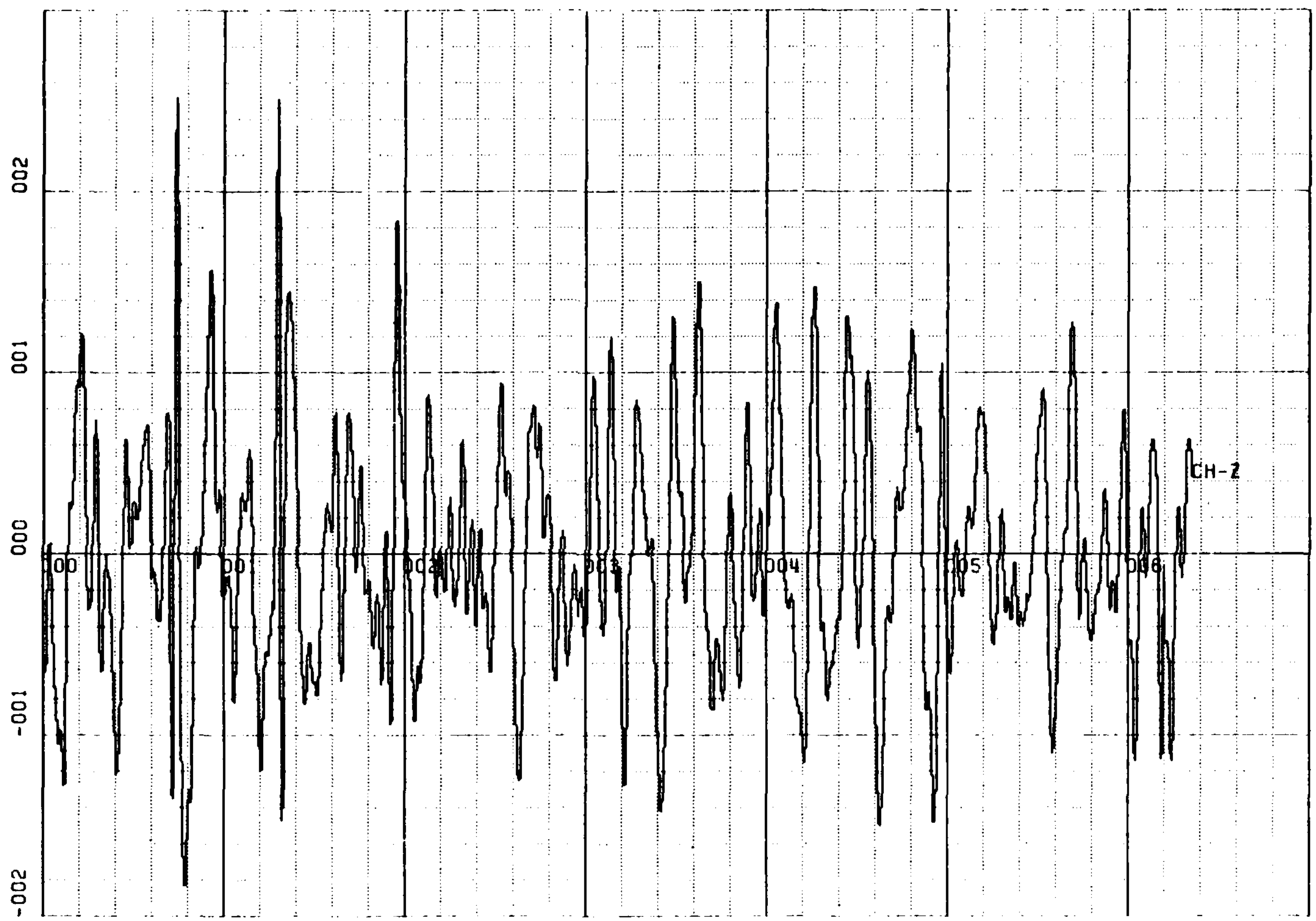


Figure 6 1 Z Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.01 volts/inch) vs Time (100 seconds/inch).

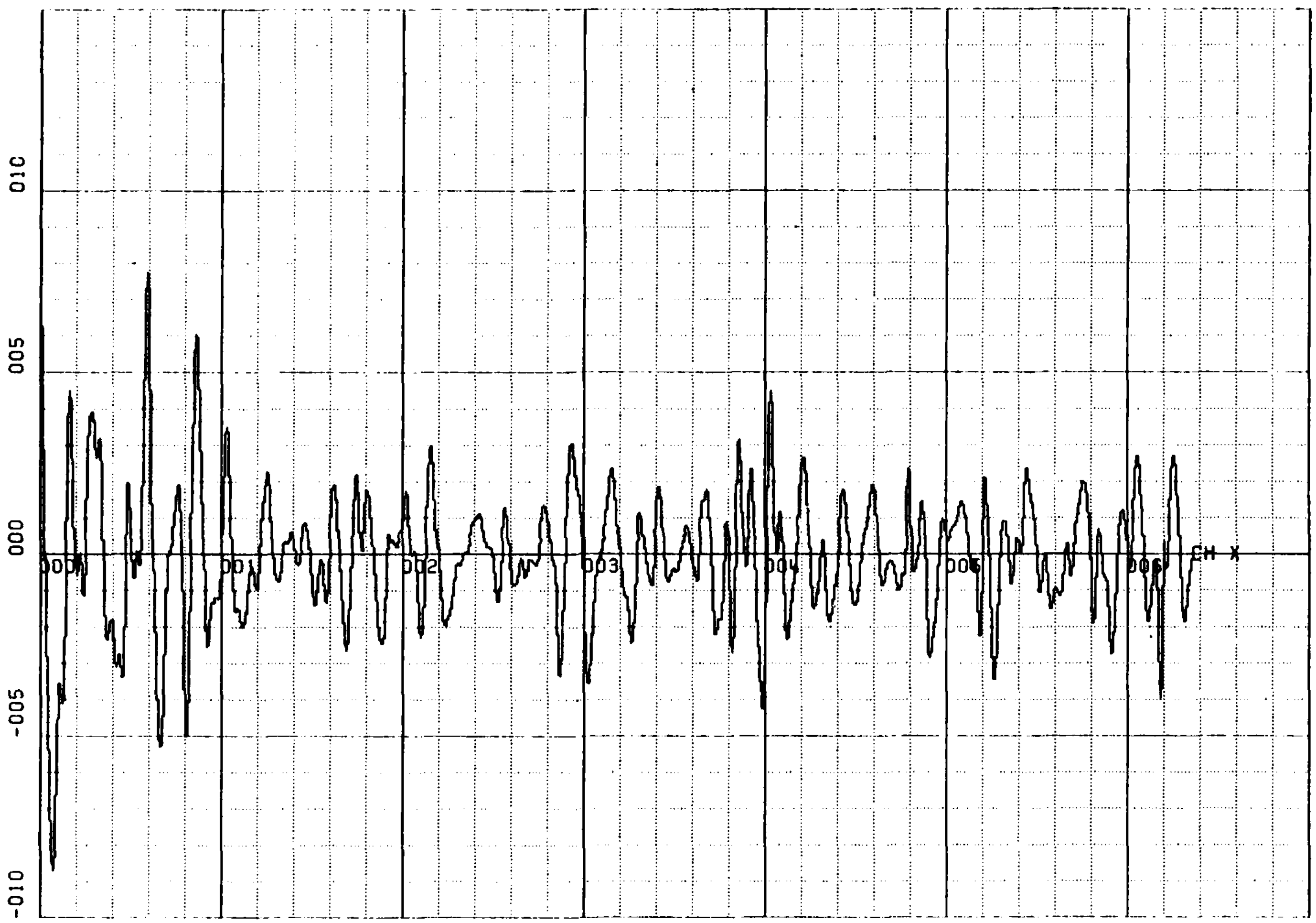


Figure 6.22 X Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

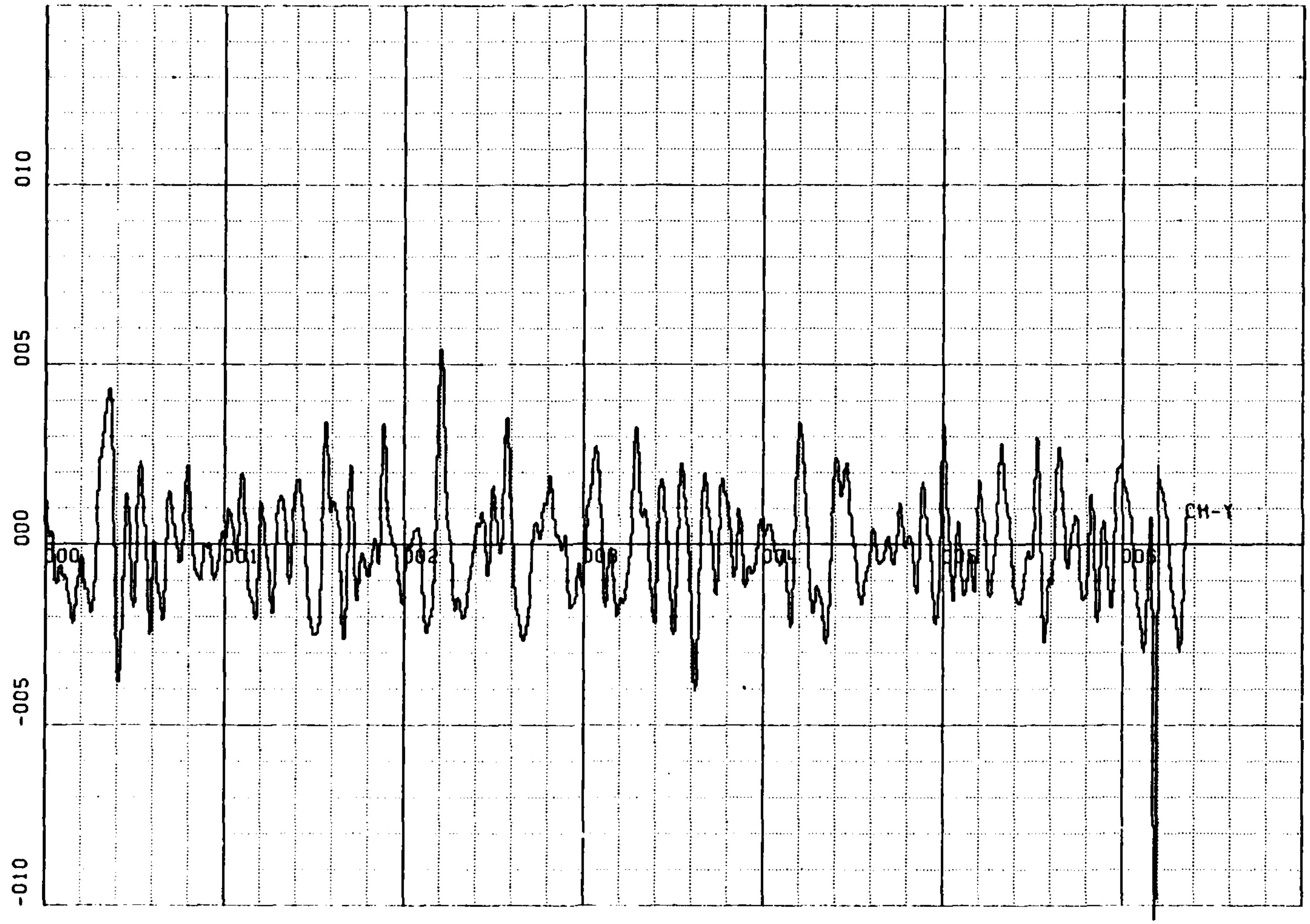


Figure 6.23 Y Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

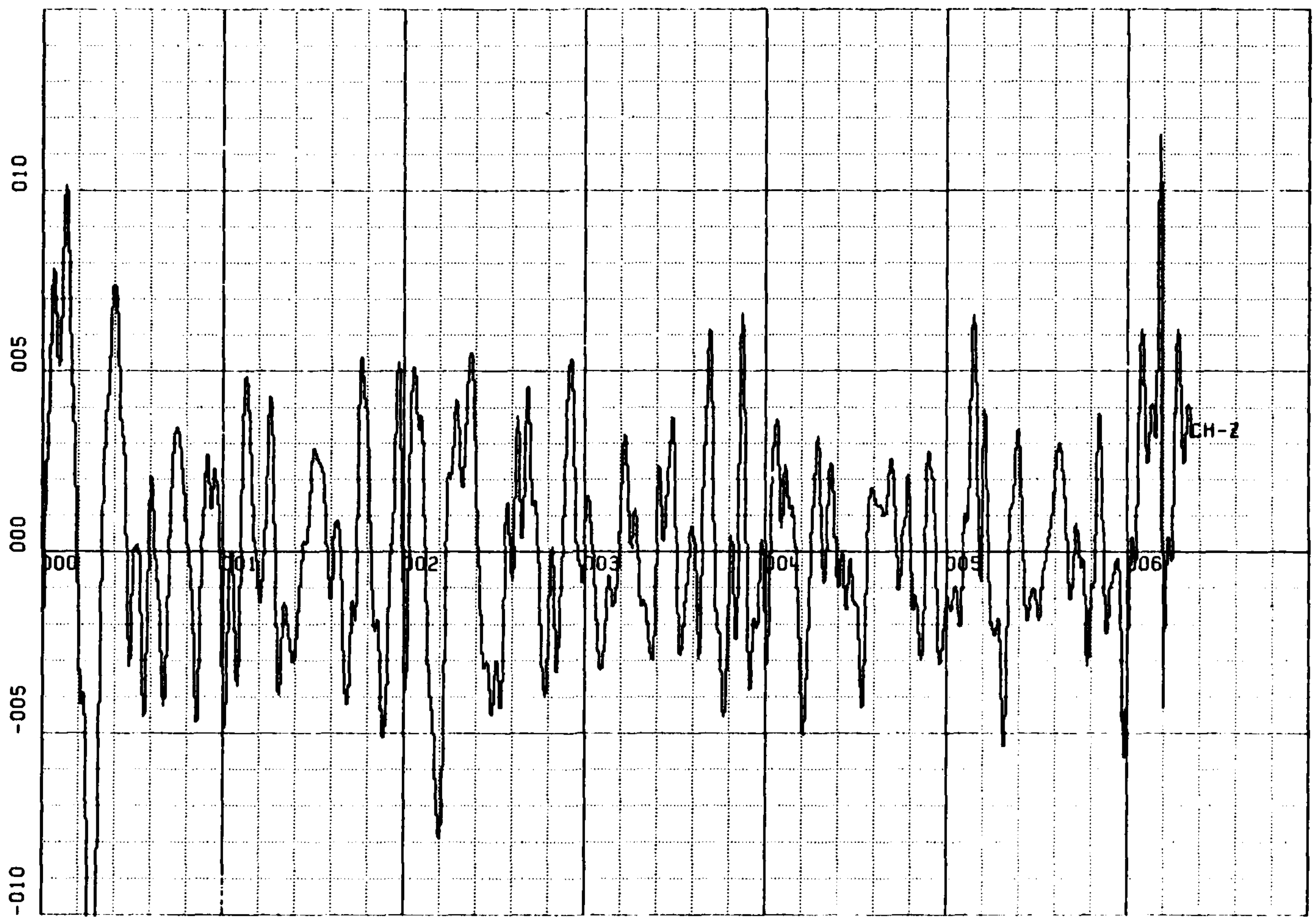


Figure 6.24 Z Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

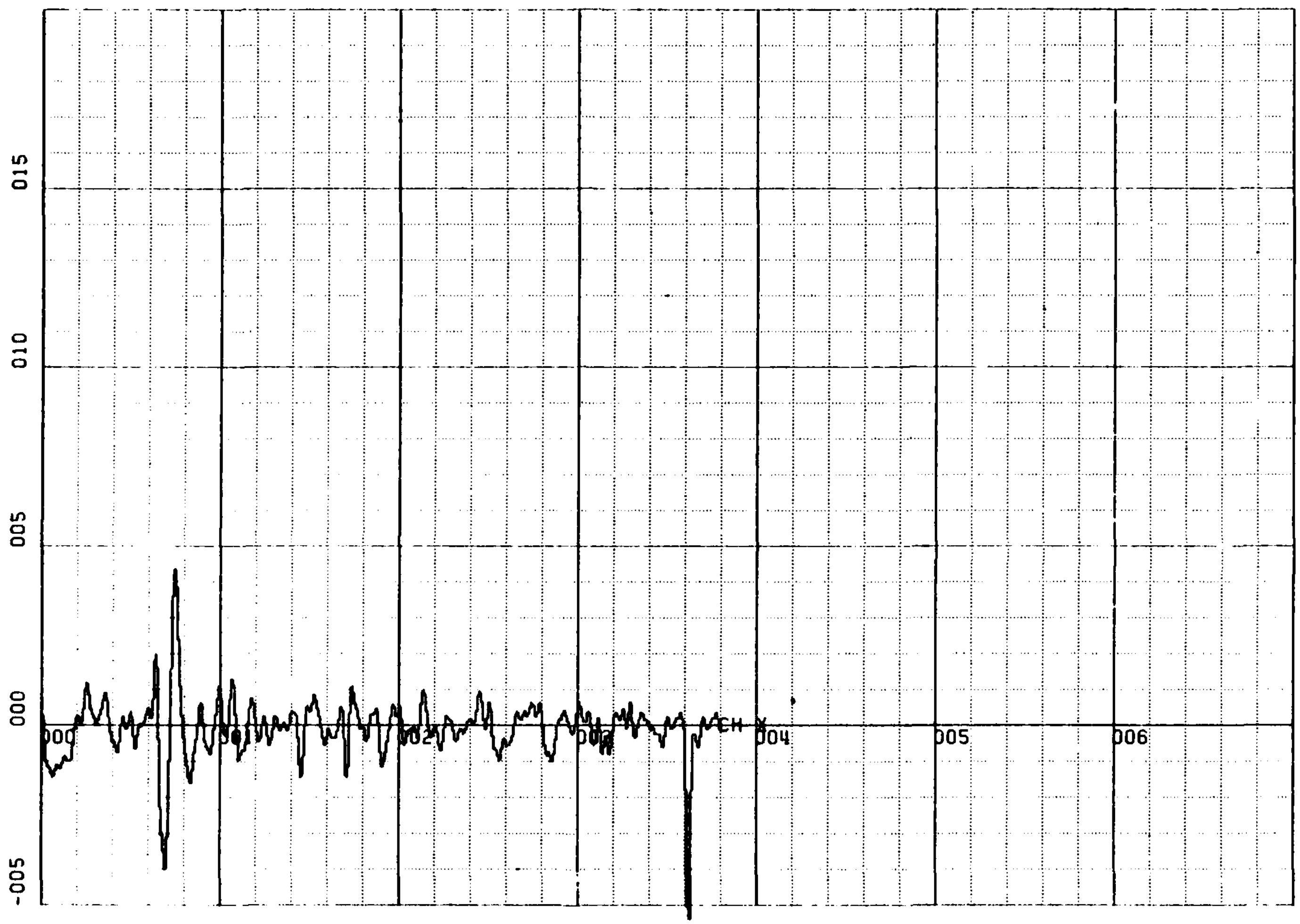


Figure 6.25 X Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

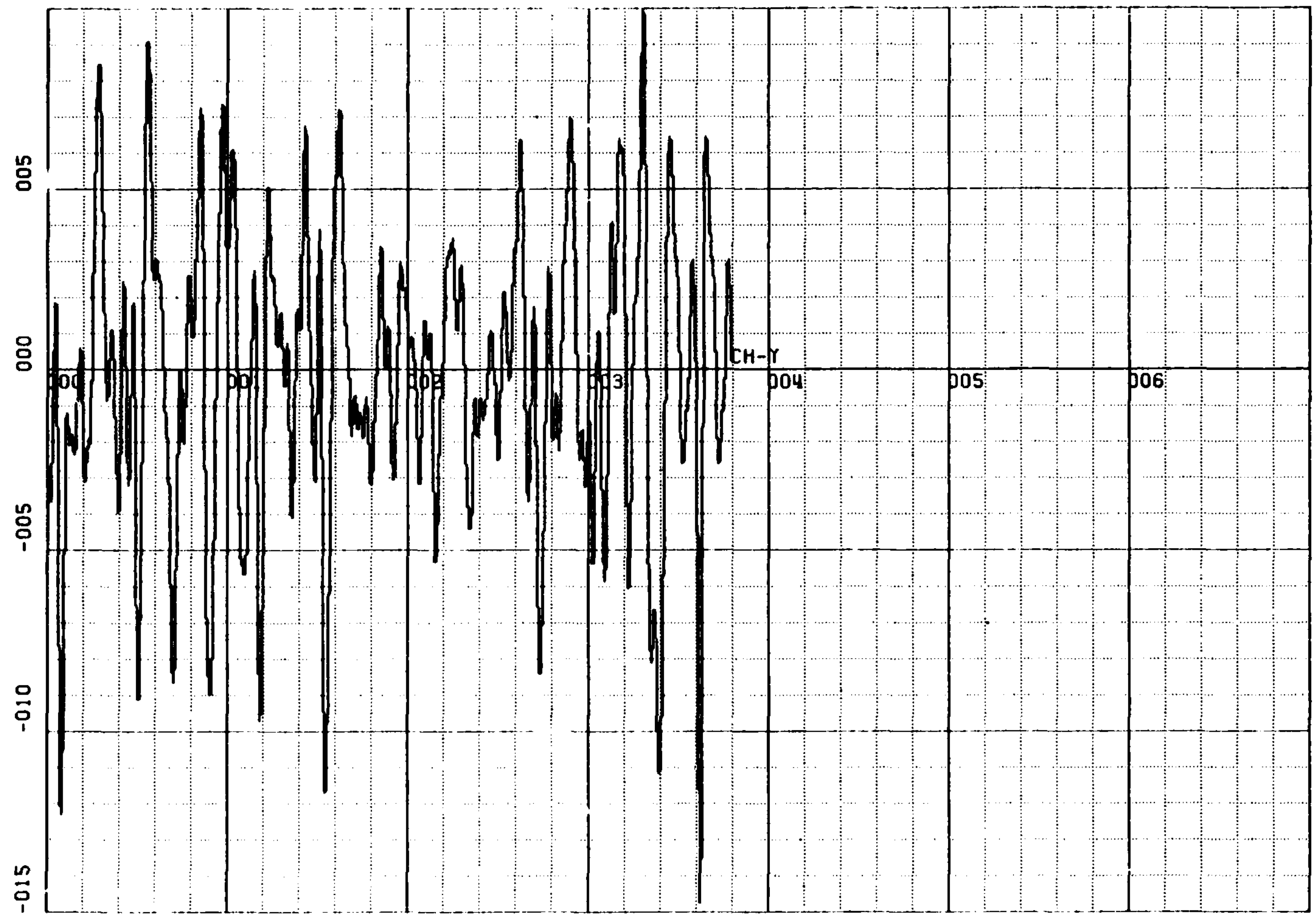


Figure 6.26 Y Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.005 volts/inch) vs Time (100 seconds/inch).

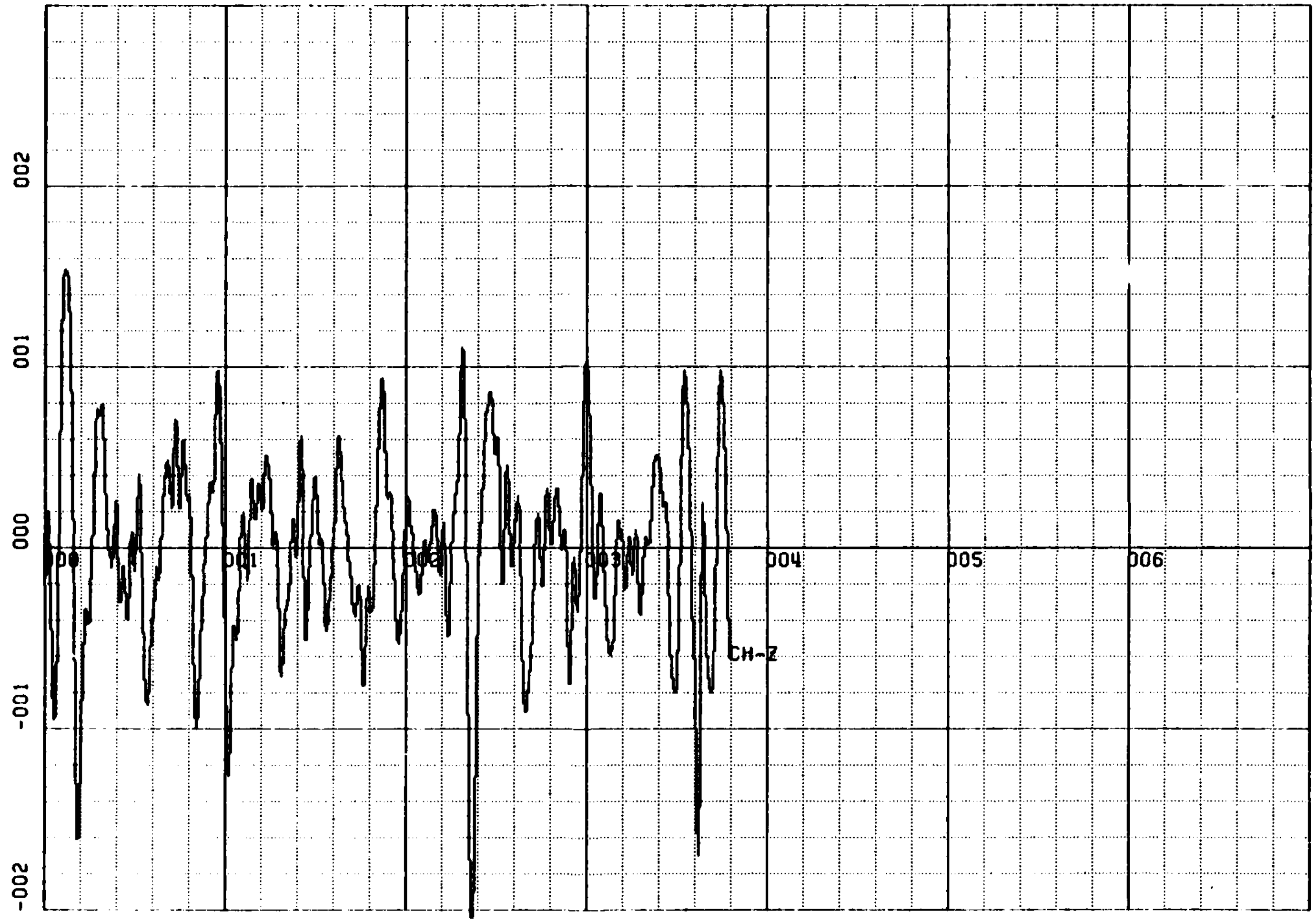


Figure 6.27 Z Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.01 volts/inch) vs Time (100 seconds/inch).

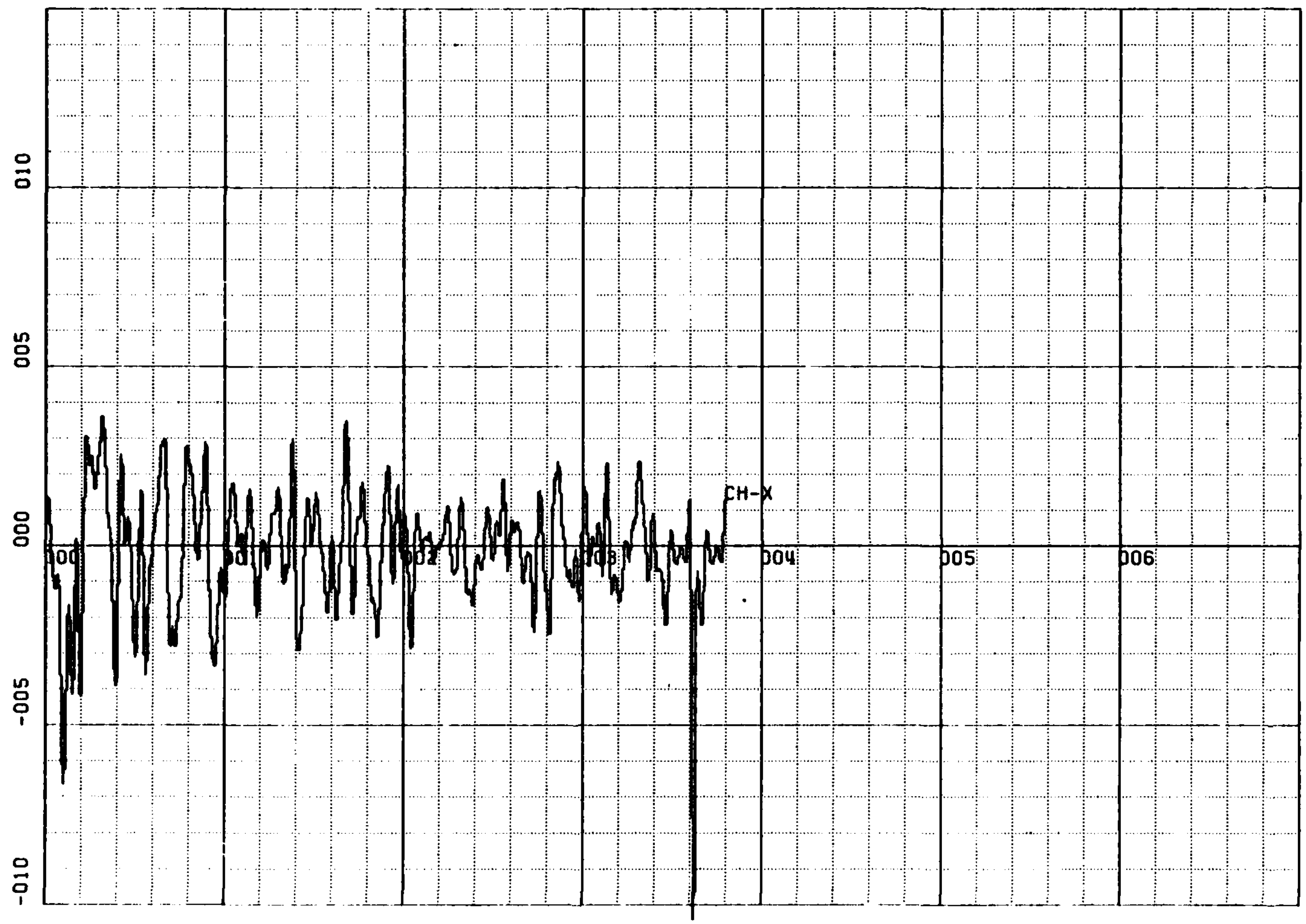


Figure 6.28 X Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

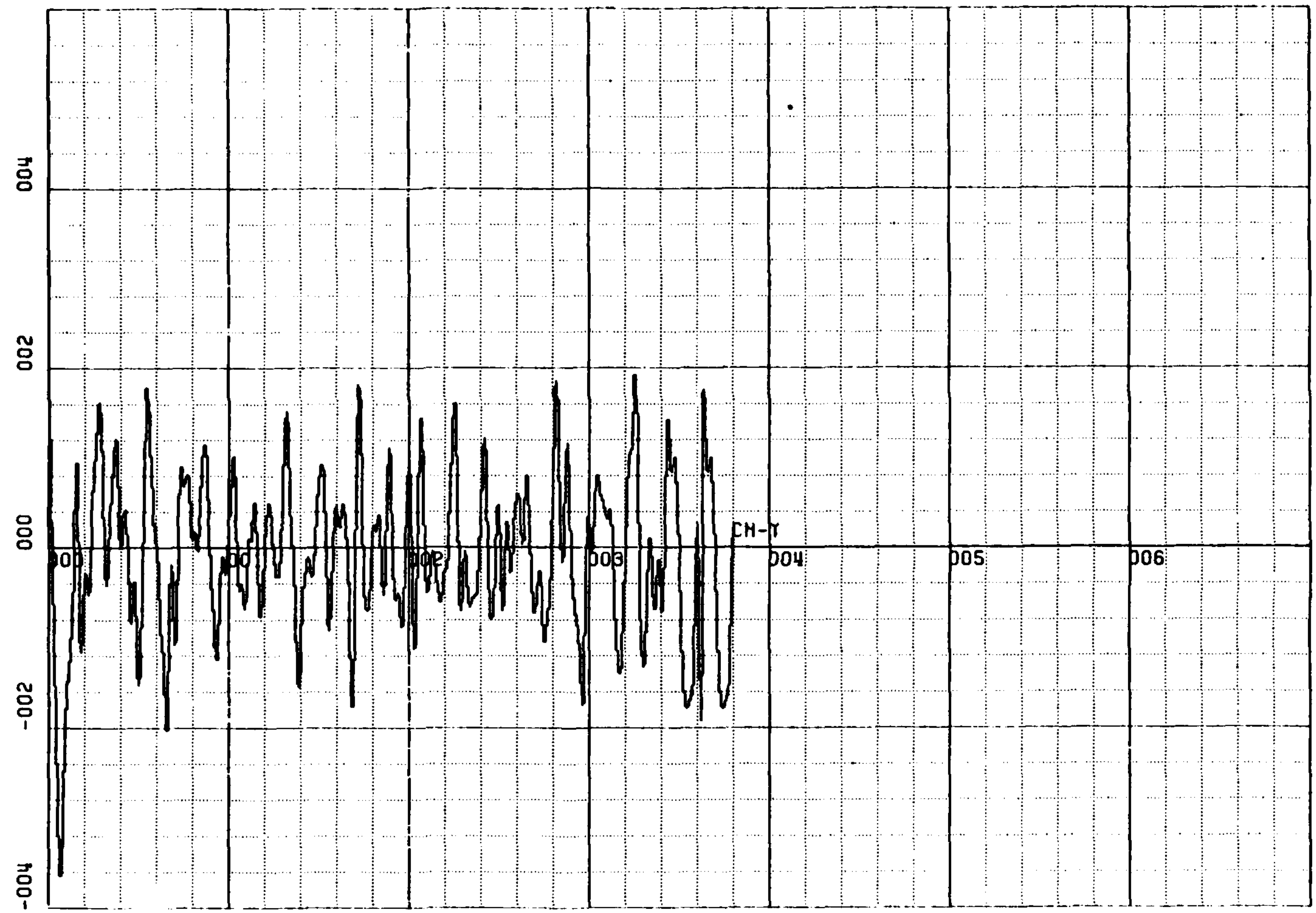


Figure 6.29 Y Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

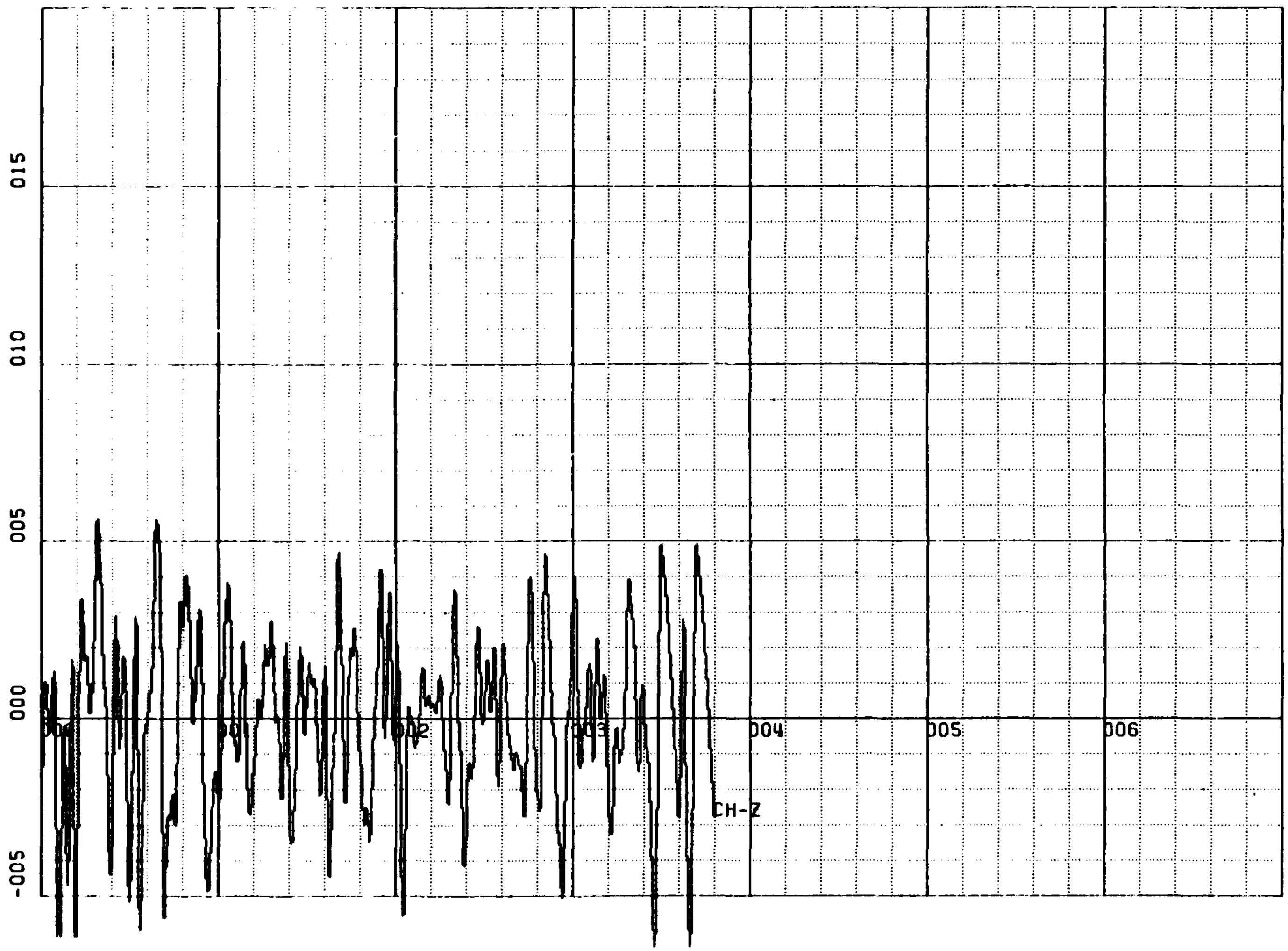


Figure 6.30 Z Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

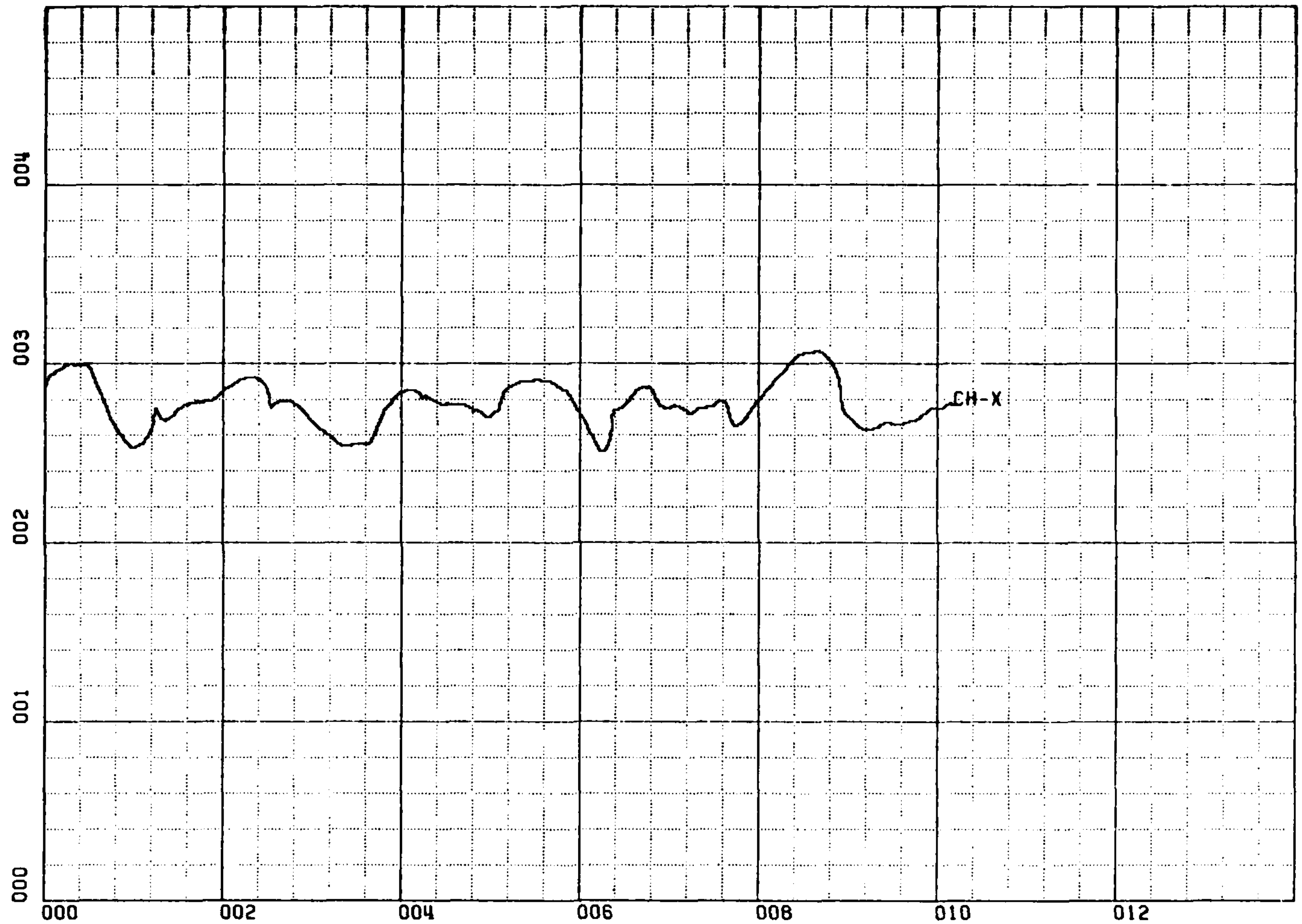


Figure 6.31 X Coil Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

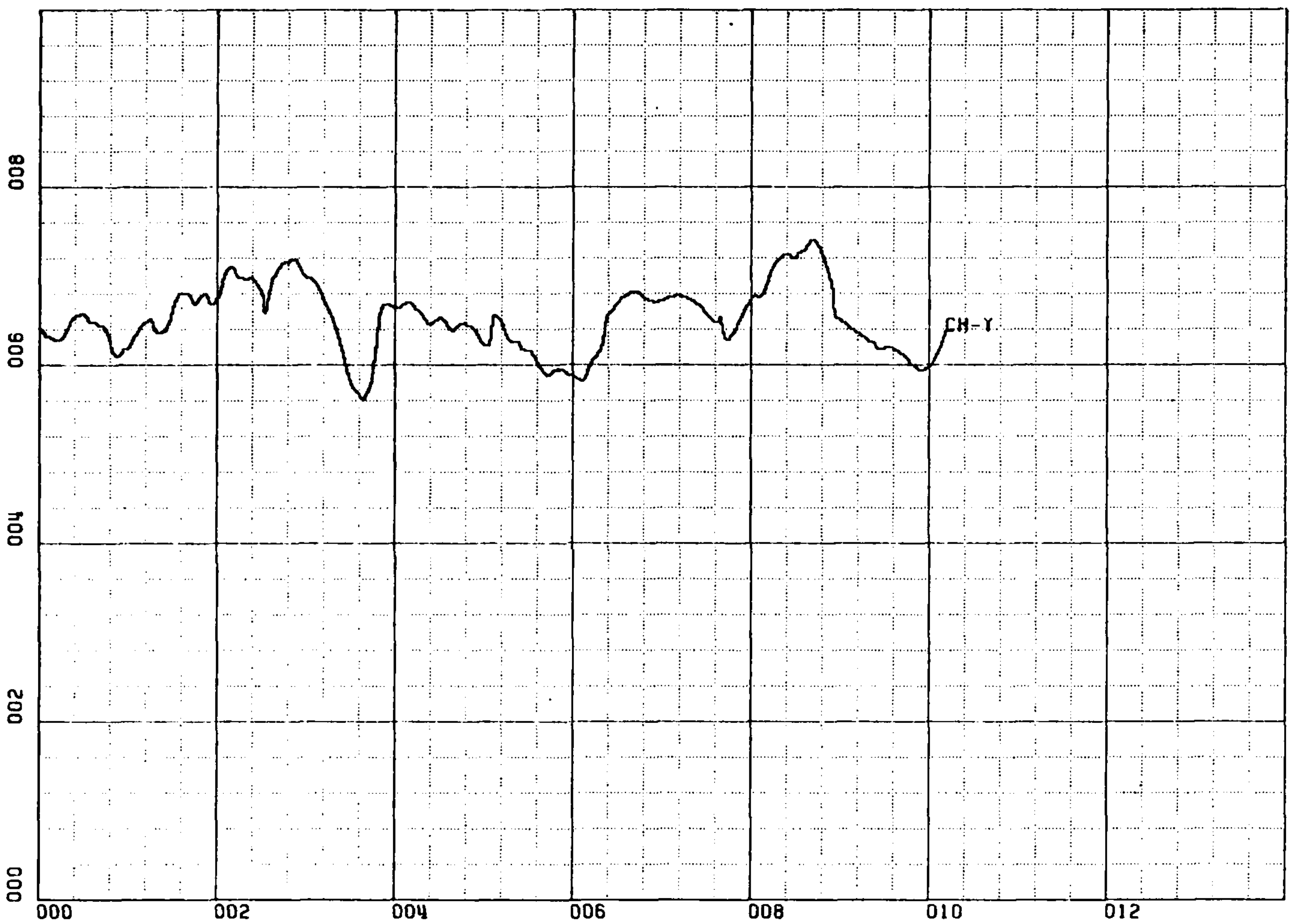


Figure 6.32 Y Coil Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (20 nanoteslas/inch) vs Time (200 seconds/inch).

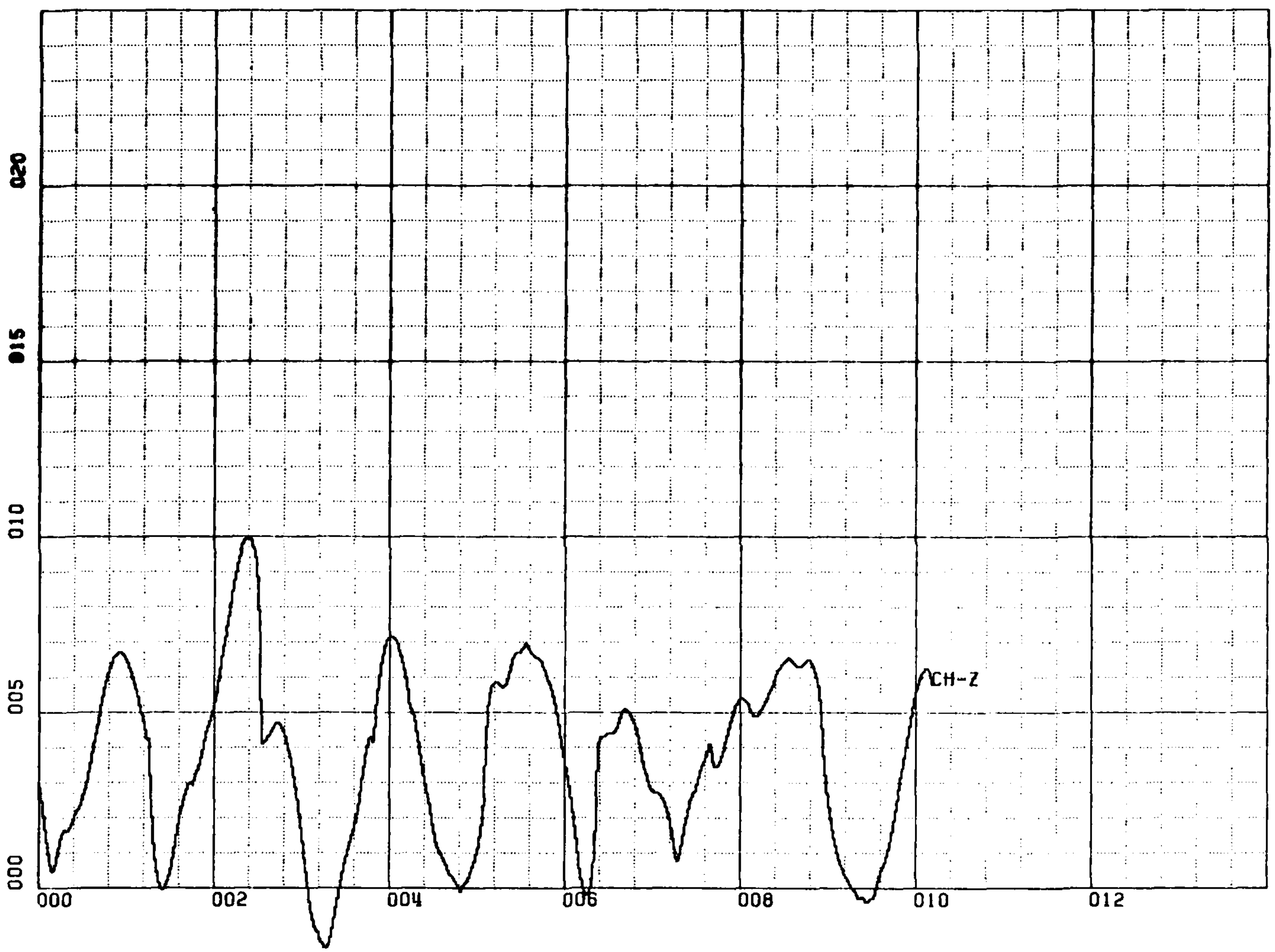


Figure 6.33 X Coil Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

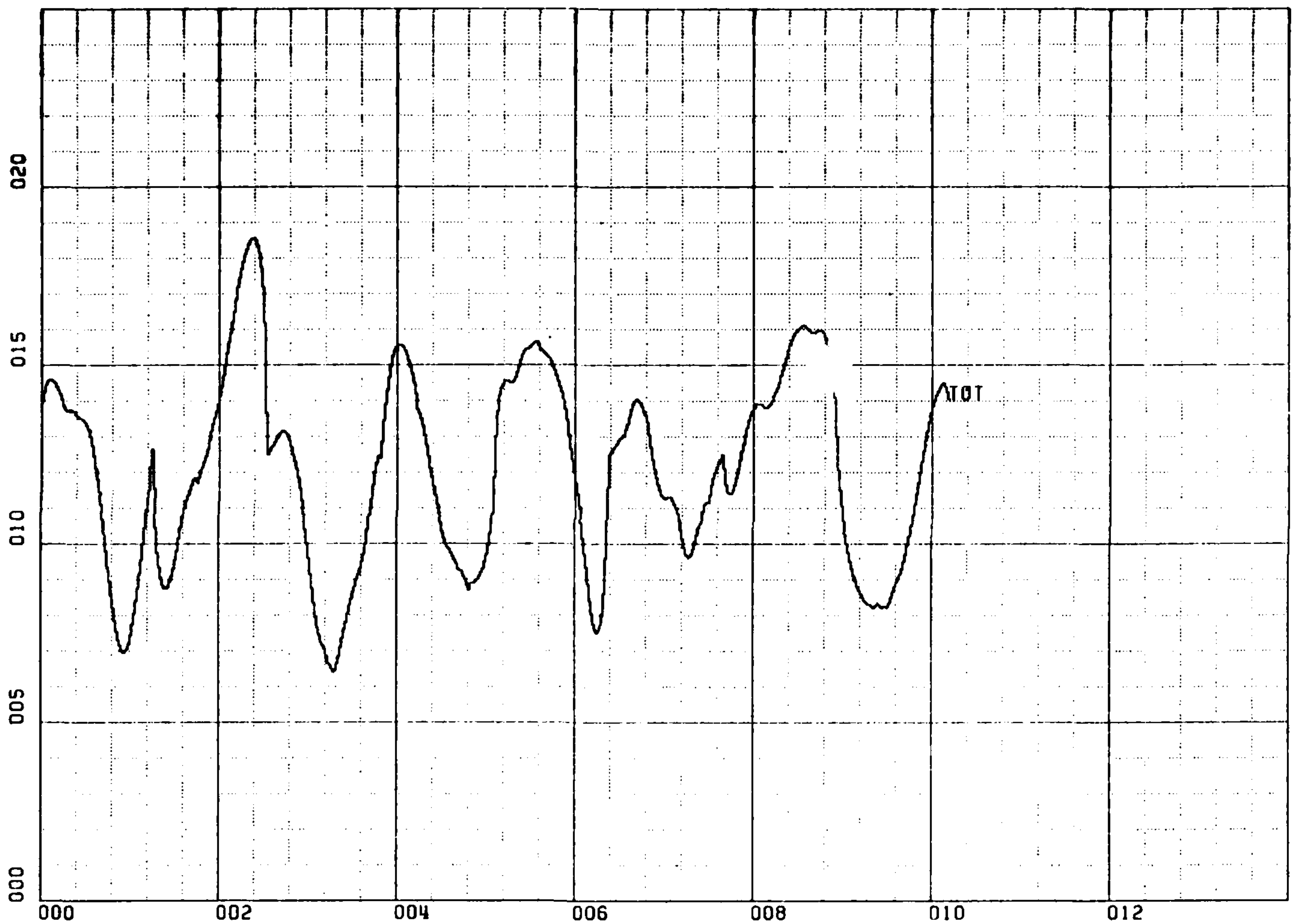


Figure 6.34 Total Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

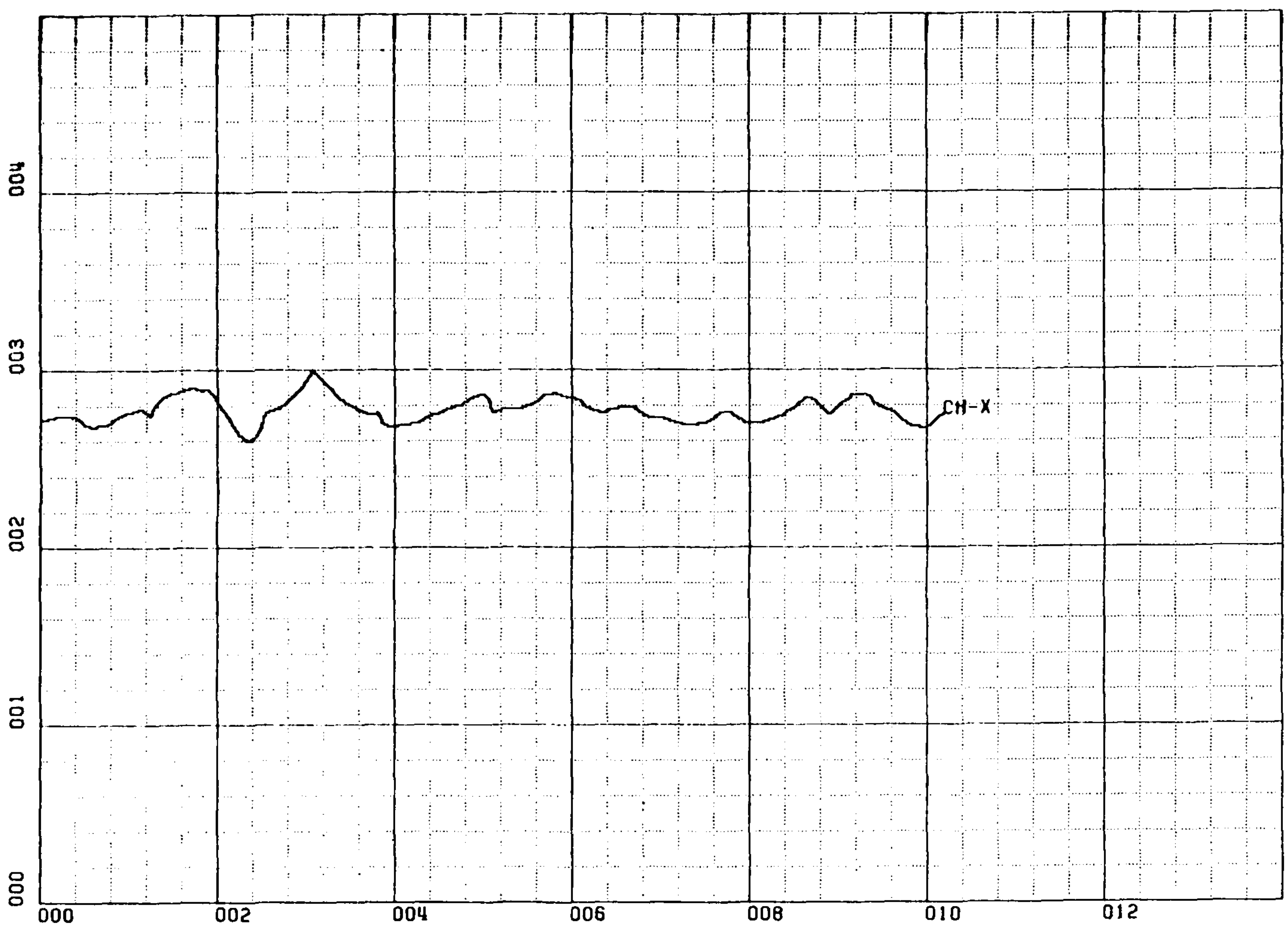


Figure 6.35 X Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

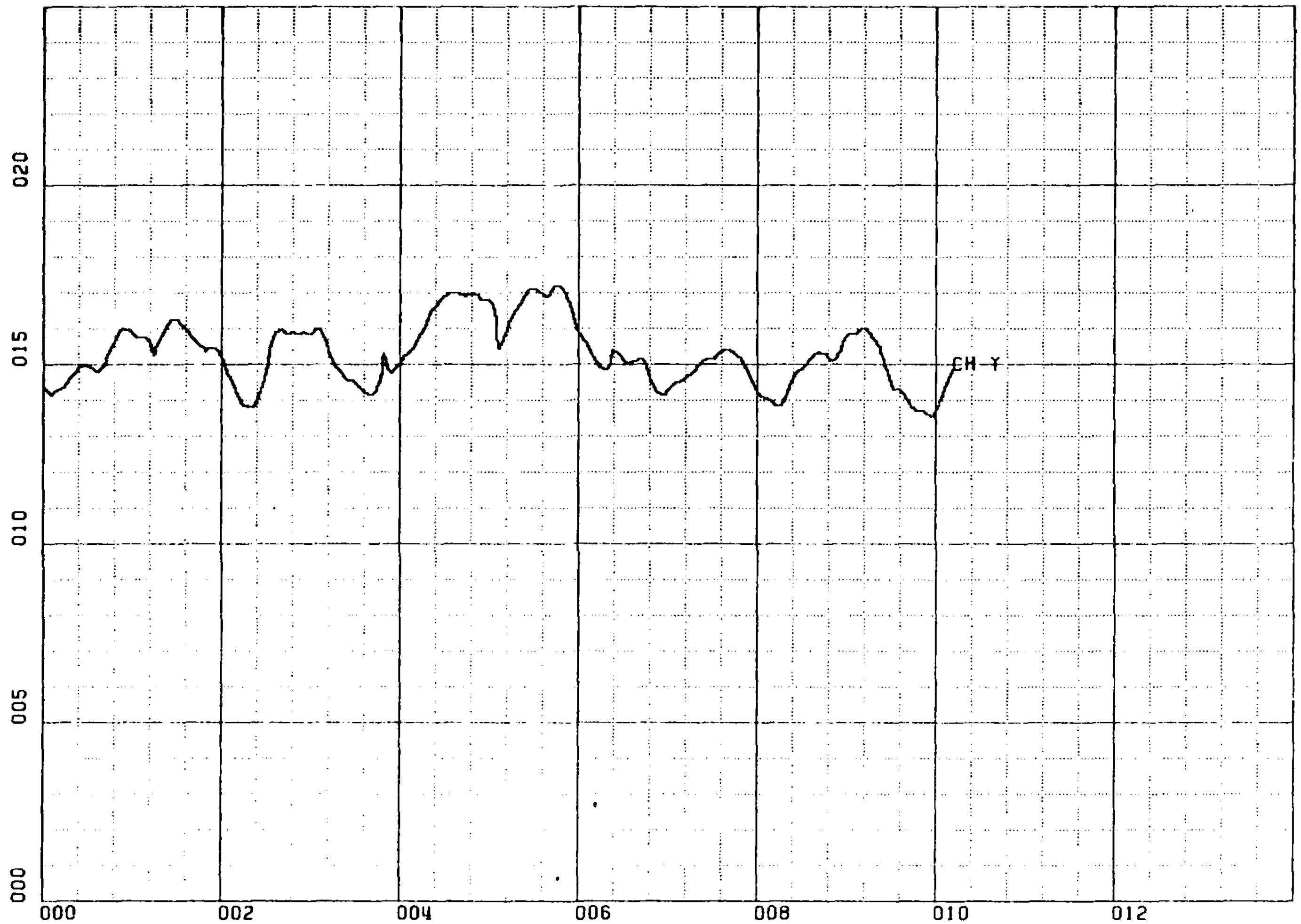


Figure 6.36 Y Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

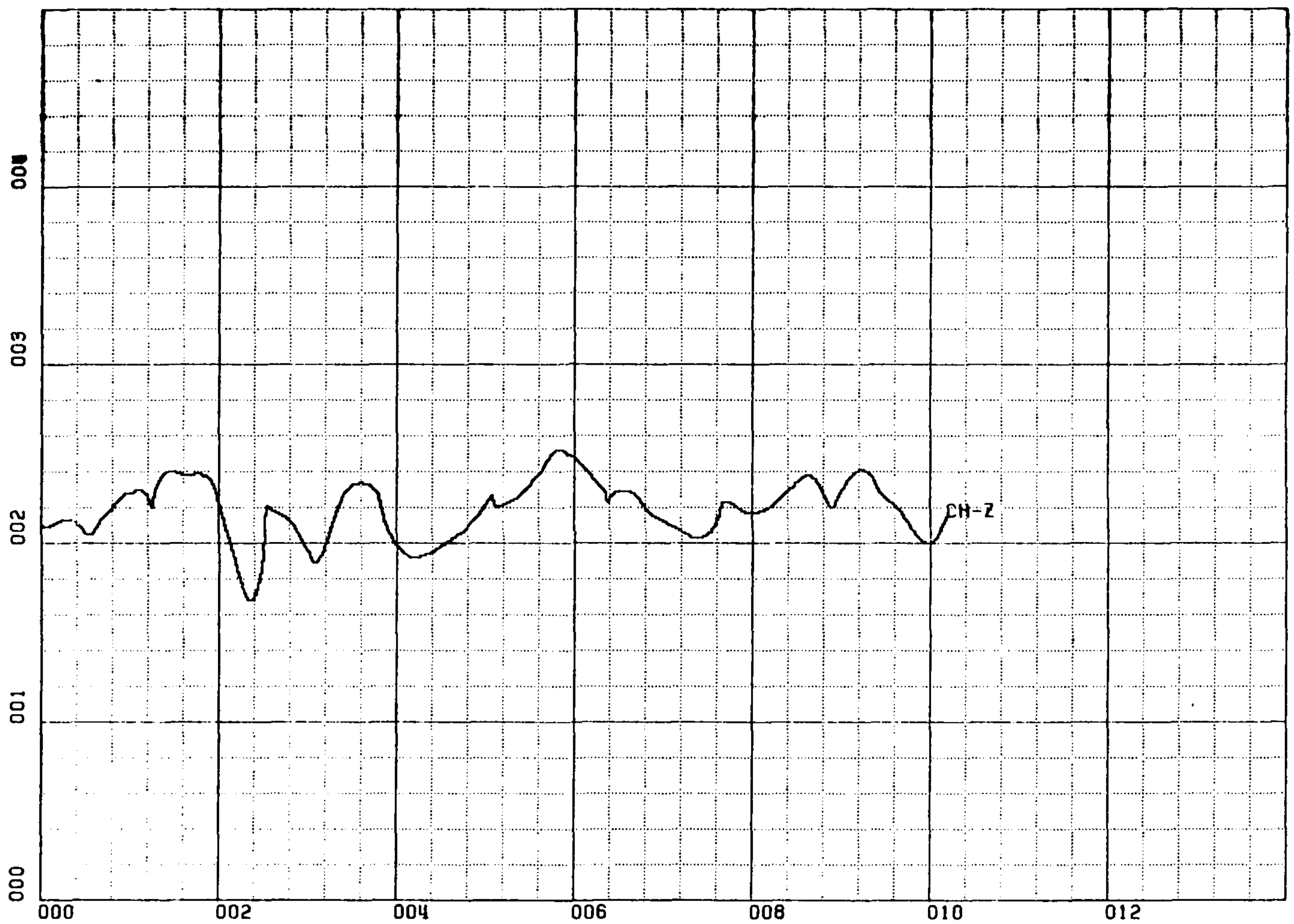


Figure 6.37 Z Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

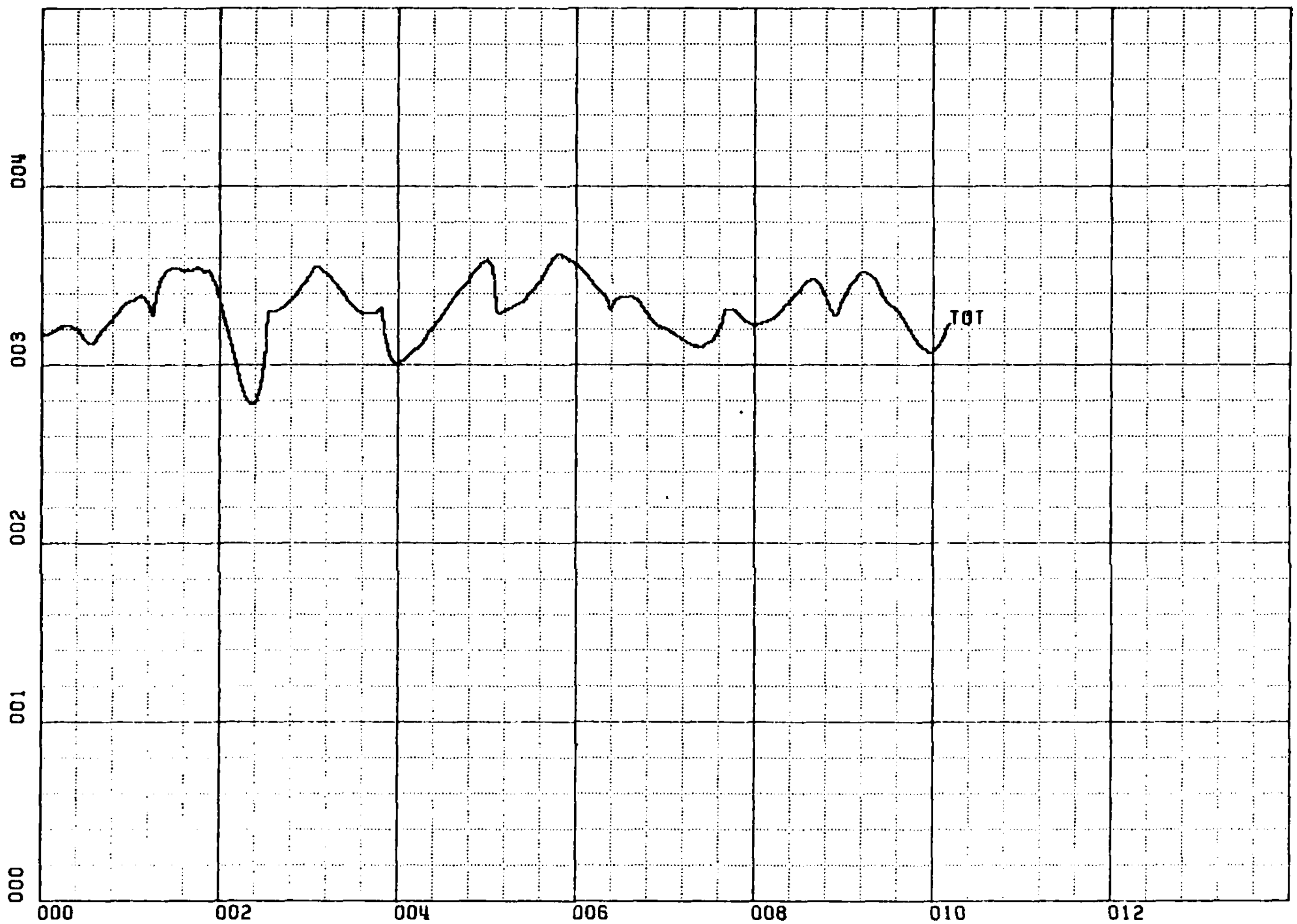


Figure 6.38 Total Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

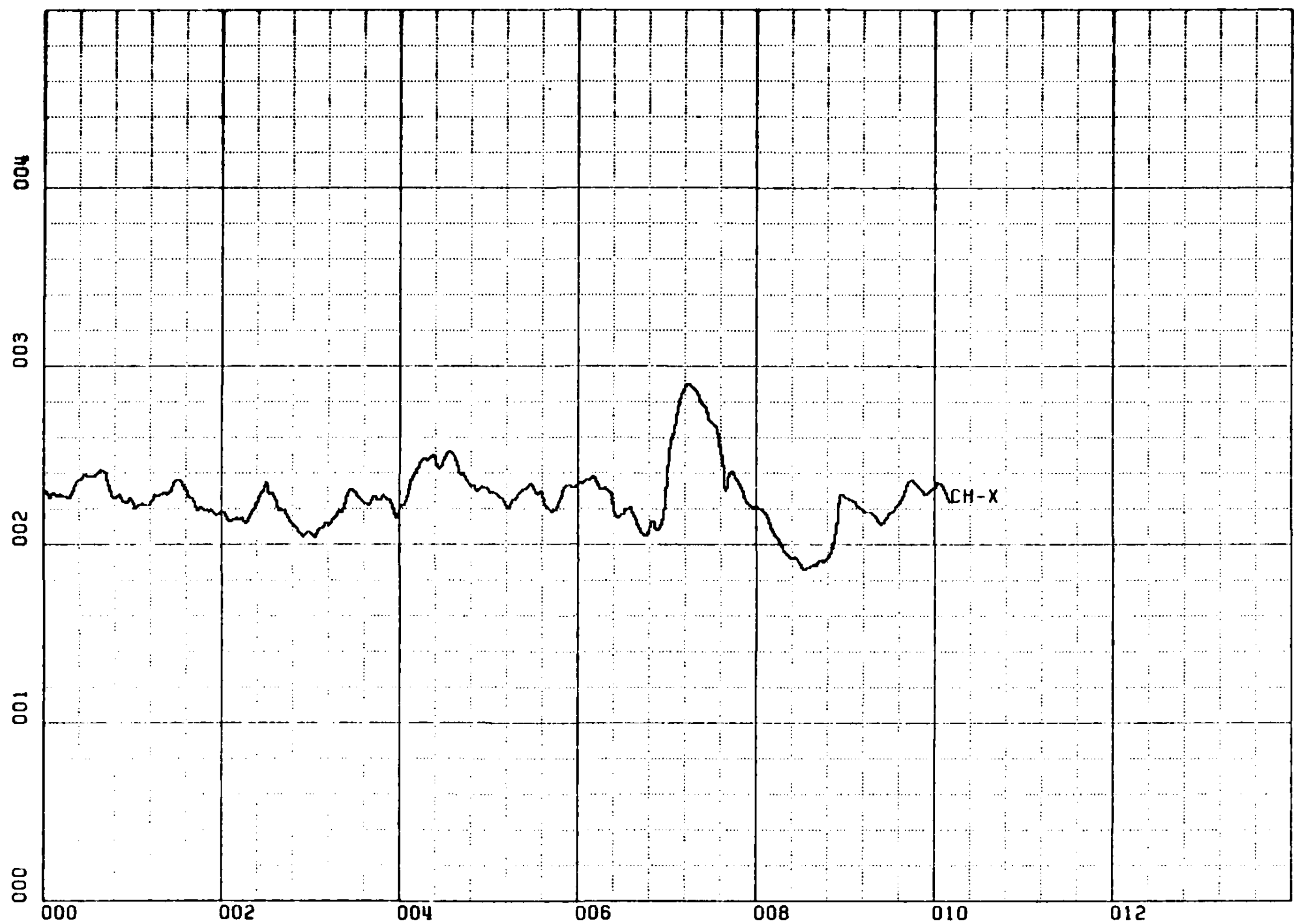


Figure 6.39 X Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

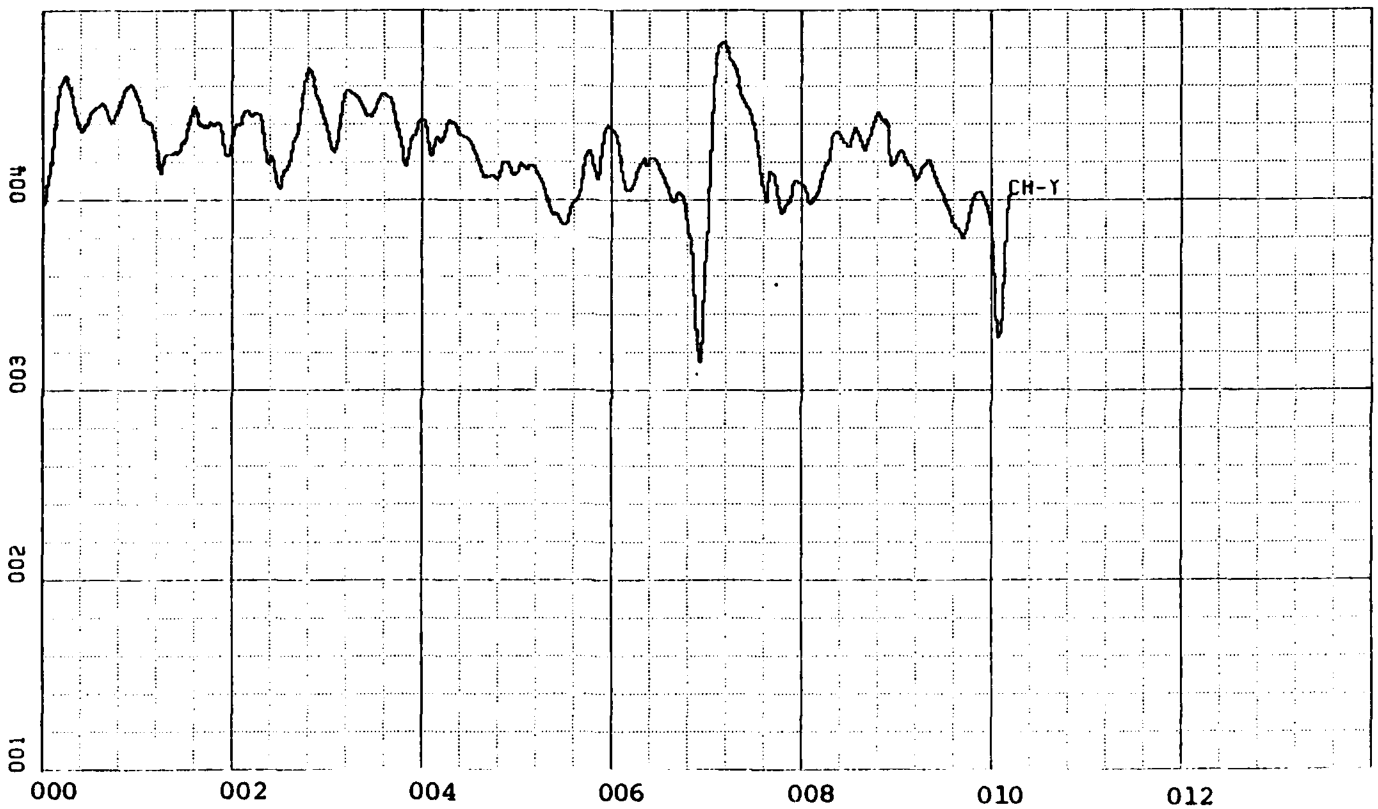


Figure 6.40   Y Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

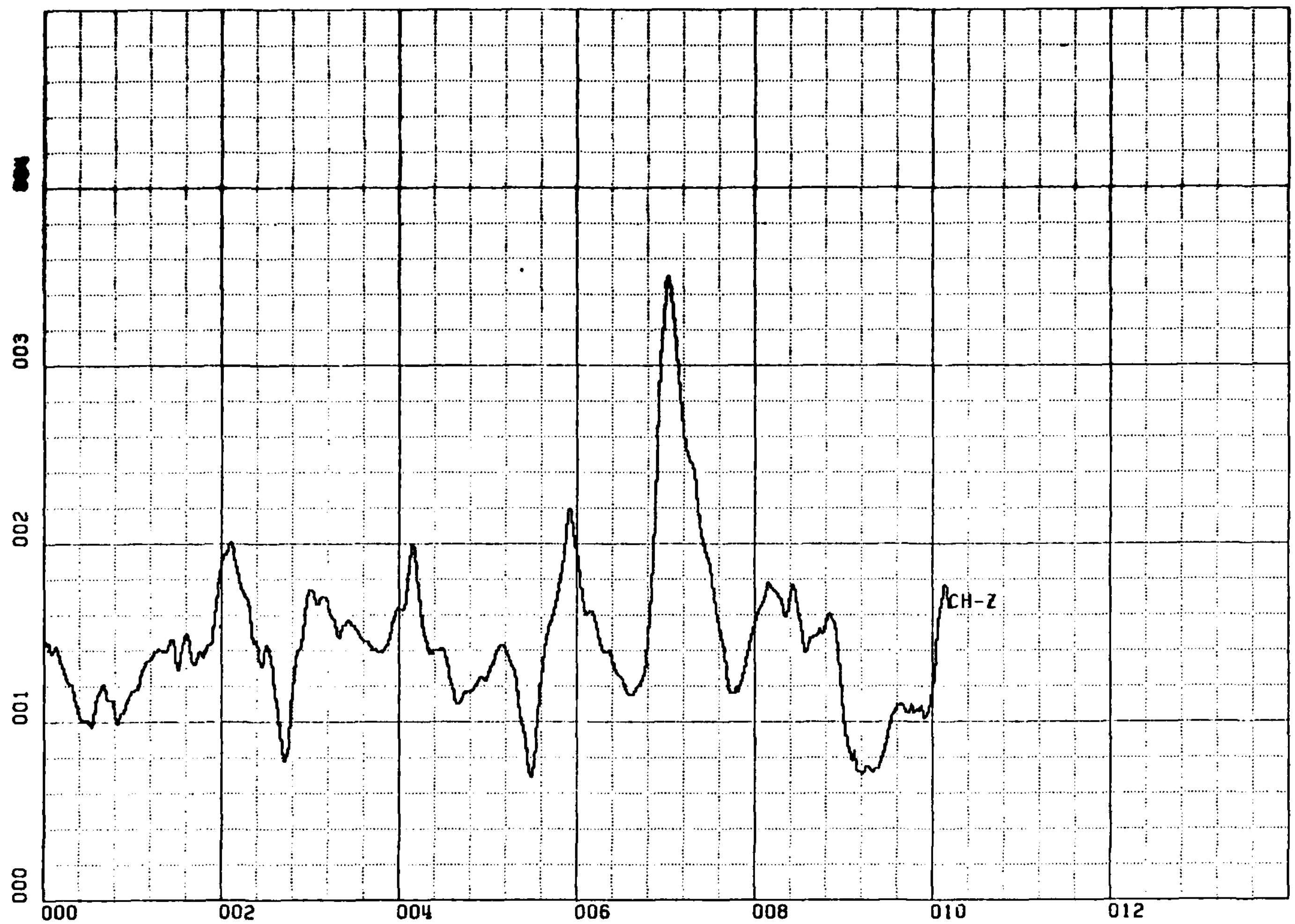


Figure 6.41 Z Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

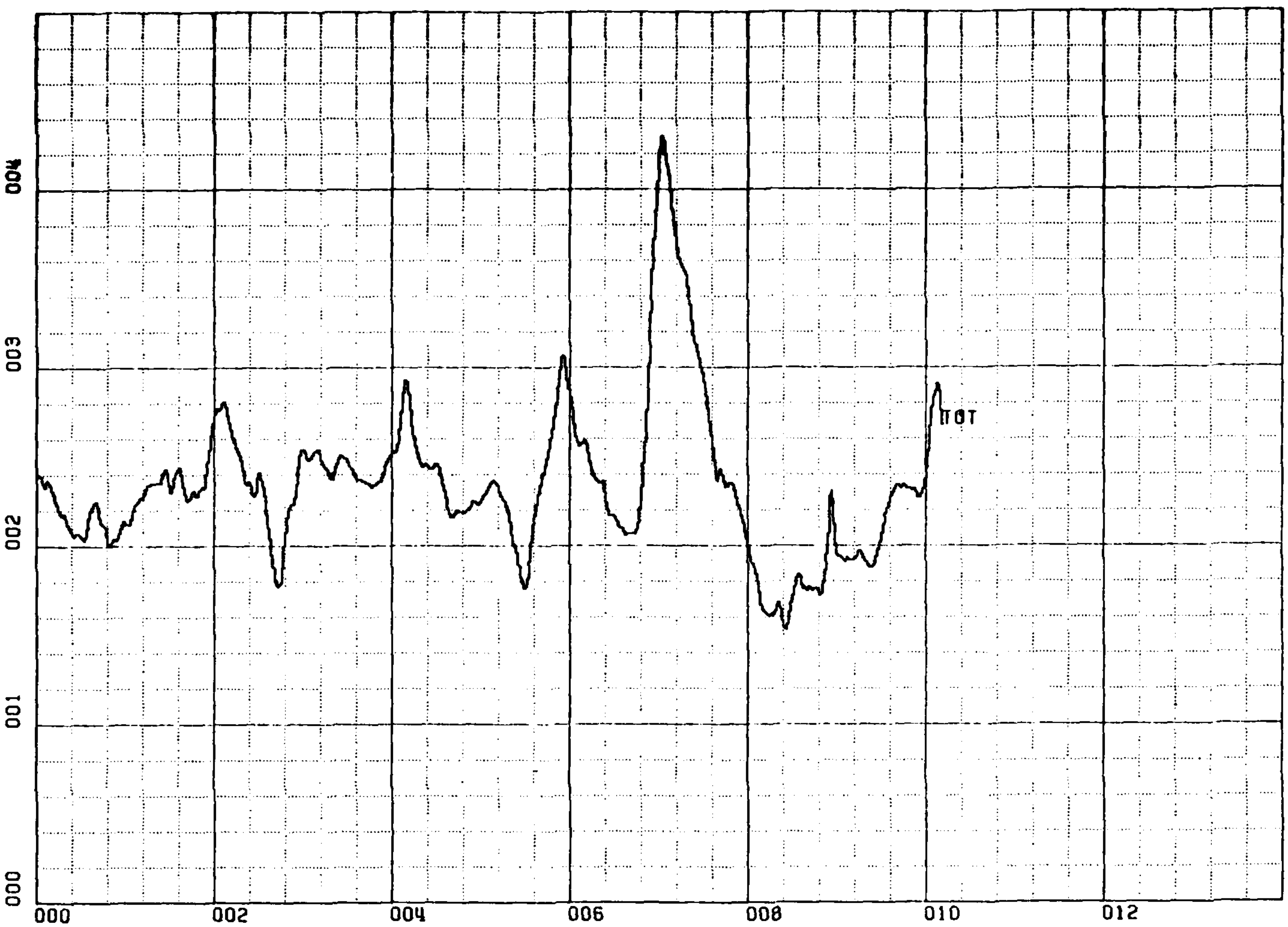


Figure 6.42 Total Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

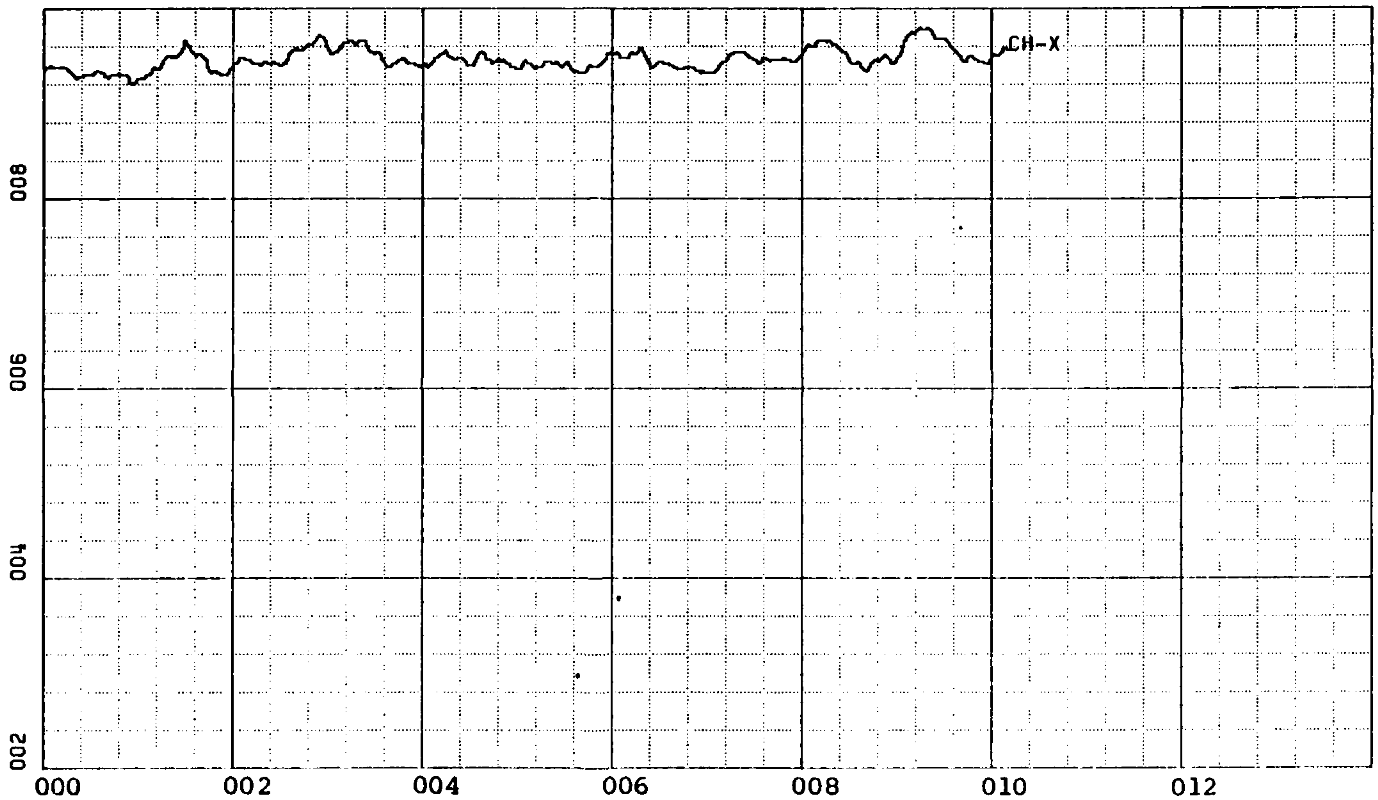


Figure 6.43 X Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (2 nanotesla/inch) vs Time (200 seconds/inch).

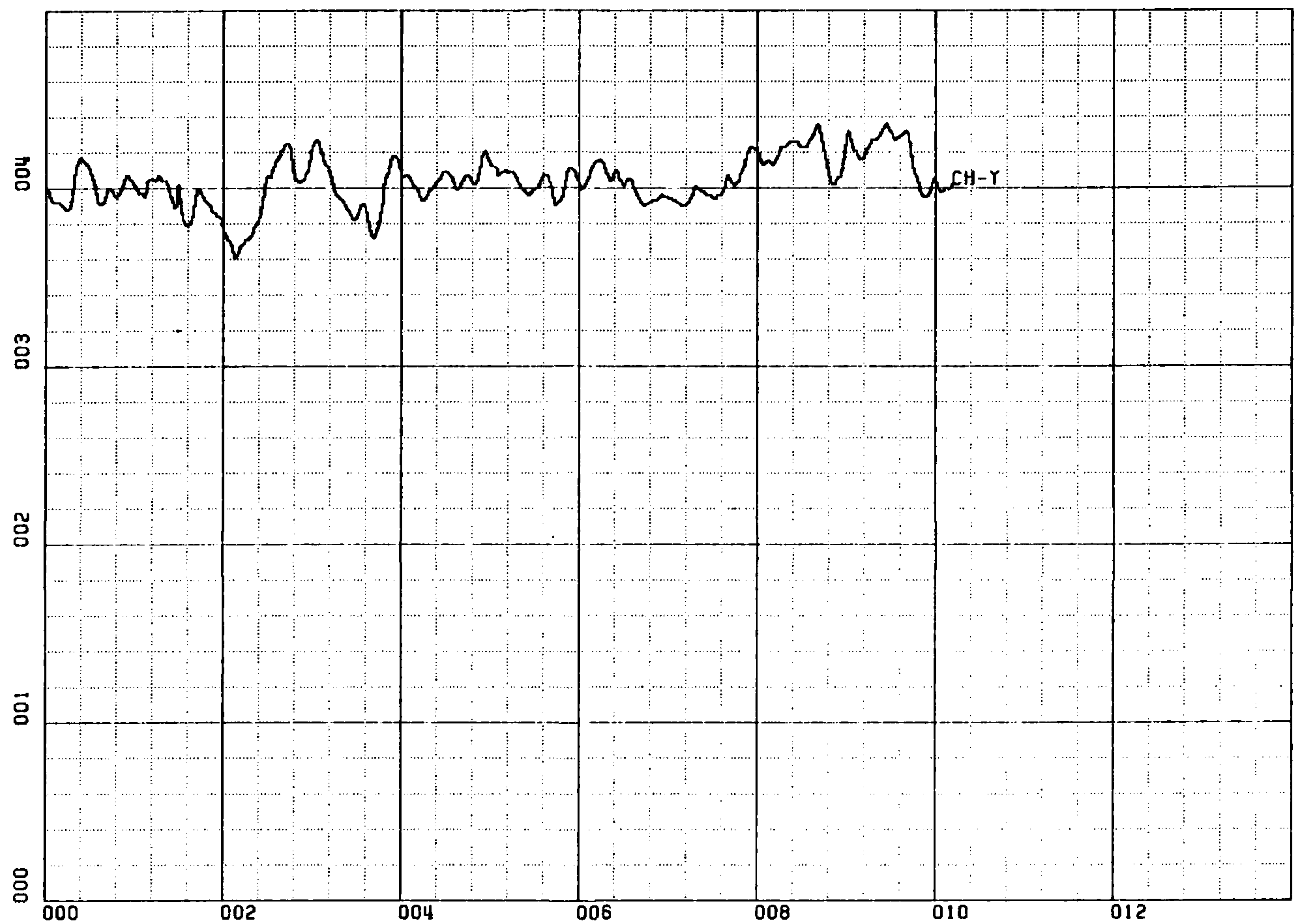


Figure 6.44 Y Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

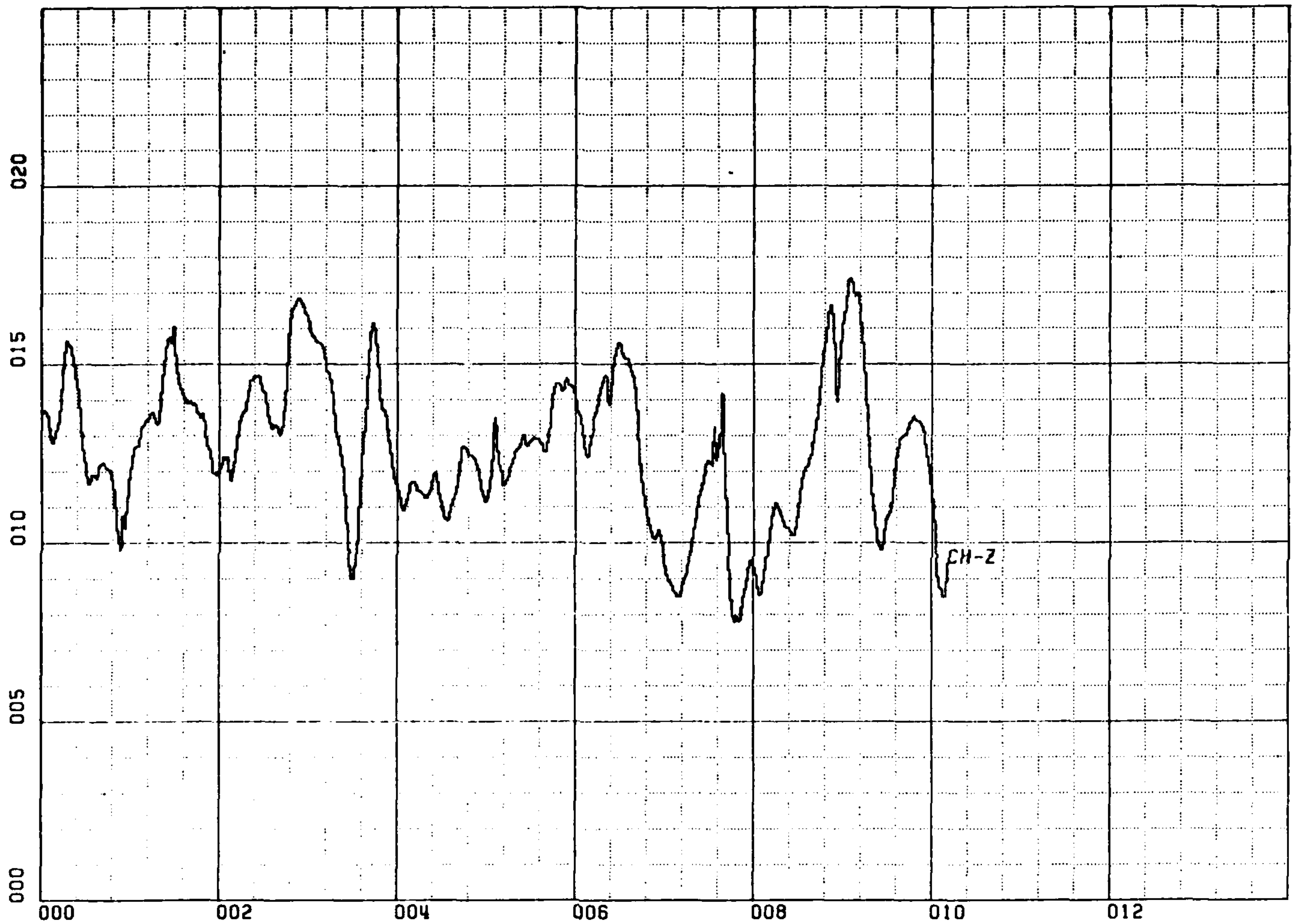


Figure 6.45 Z Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (0.5 nanotesla/inch) vs Time (200 seconds/inch).

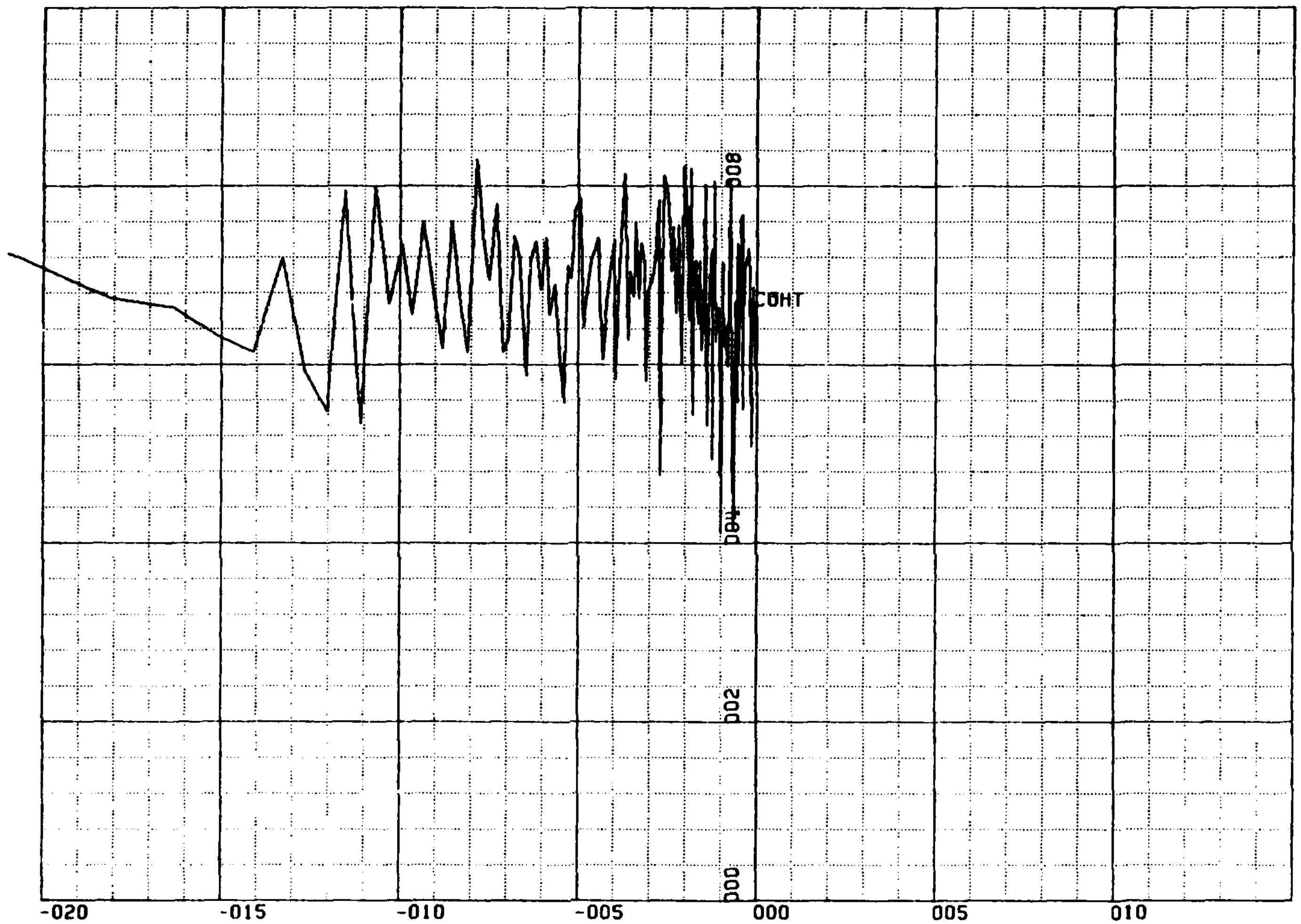


Figure 6.46 Total Field Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

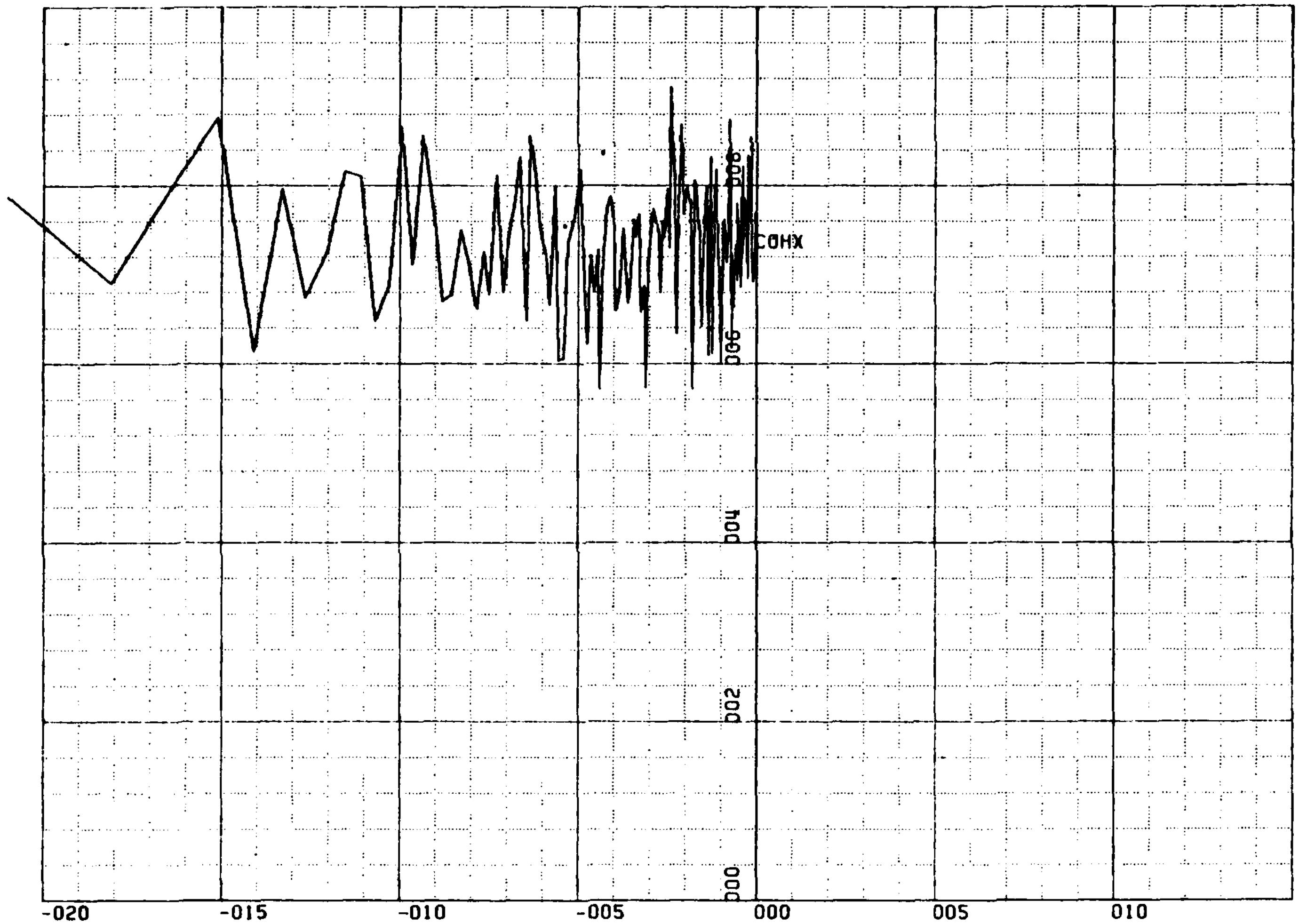


Figure 6.47 X Coil Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

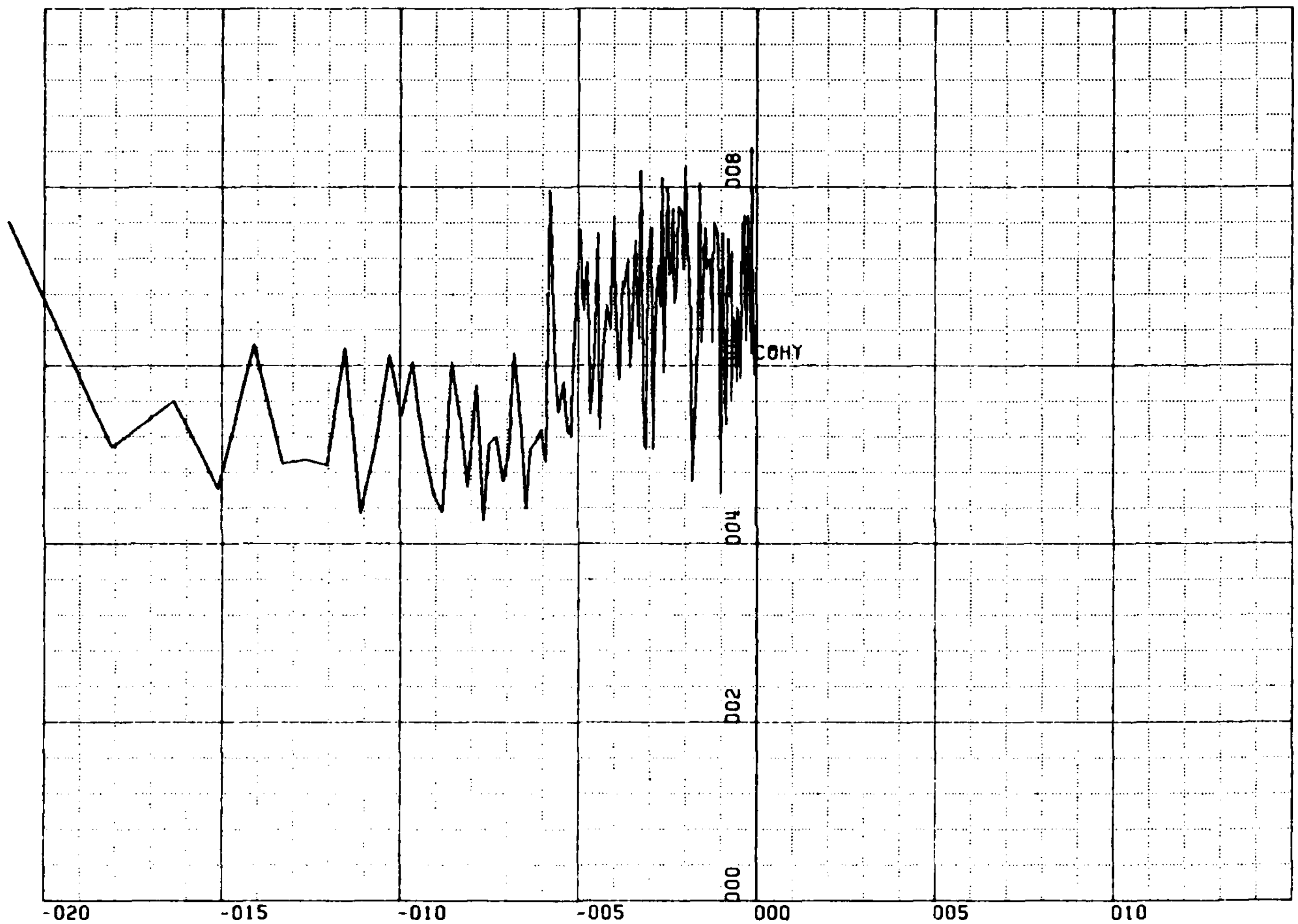


Figure 6.48 Y Coil Coherence
1310 - 1350 Local
Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/ inch).

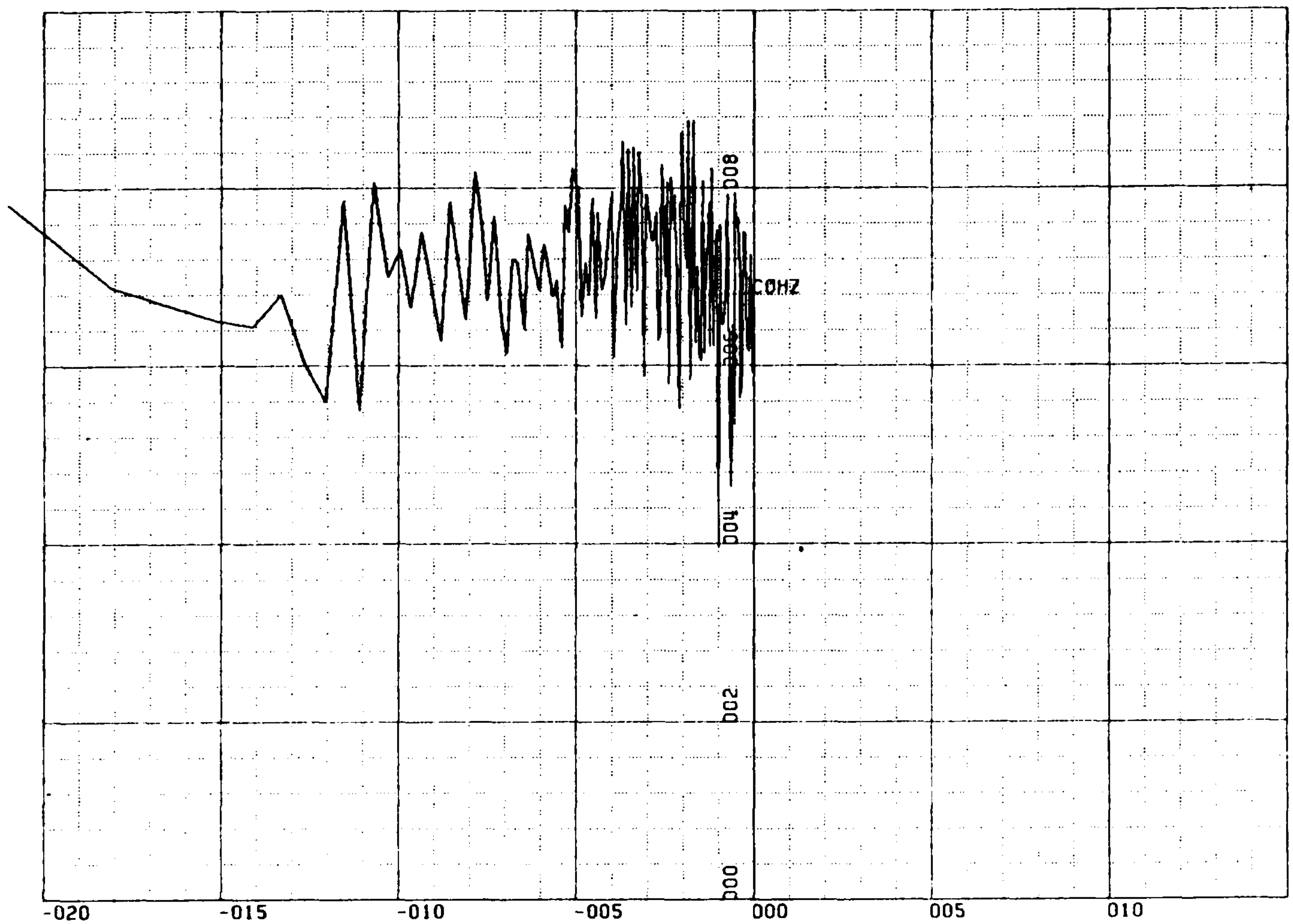


Figure 6.49 Z Coil Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

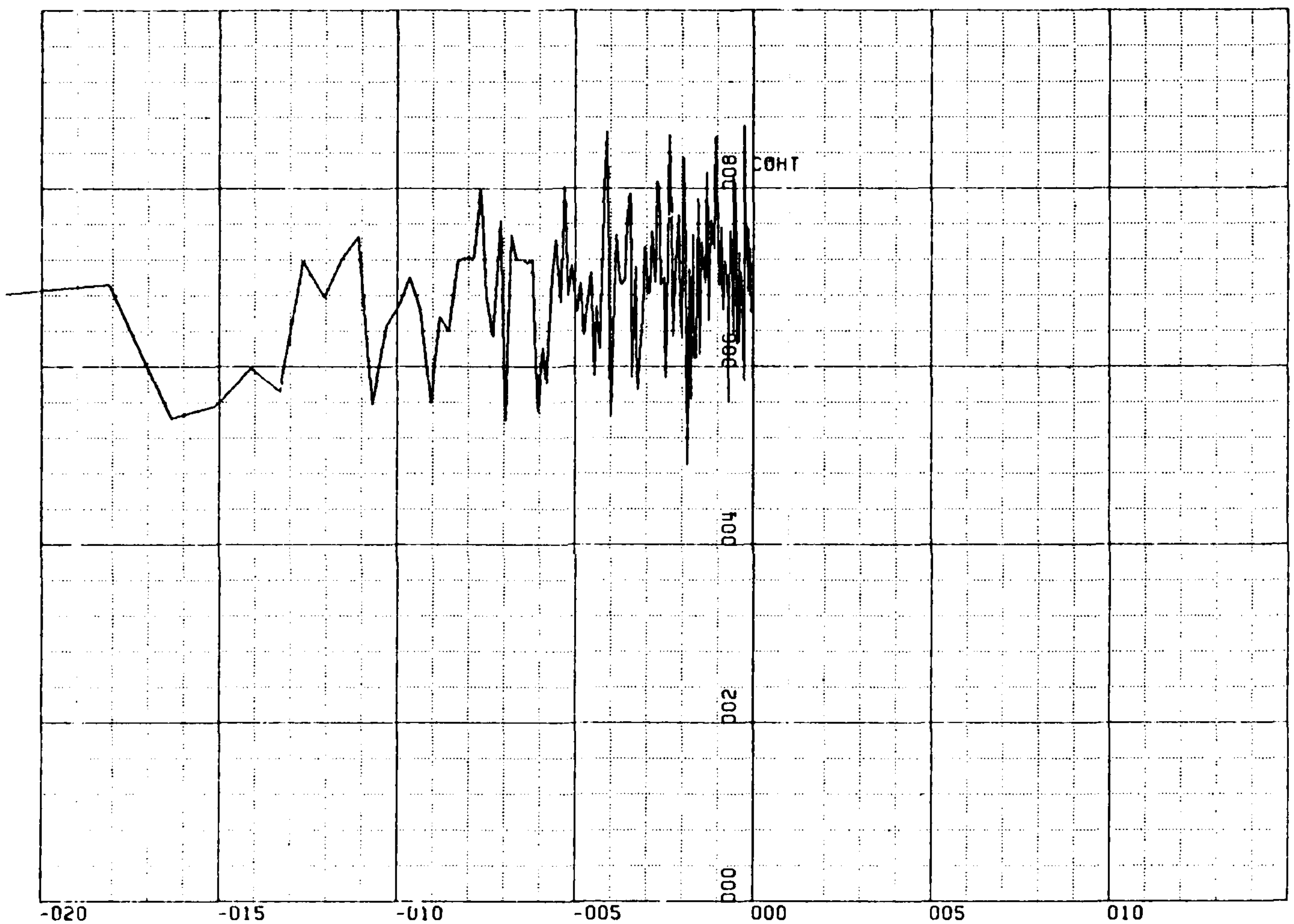


Figure 6.50 Total Field Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/ inch).

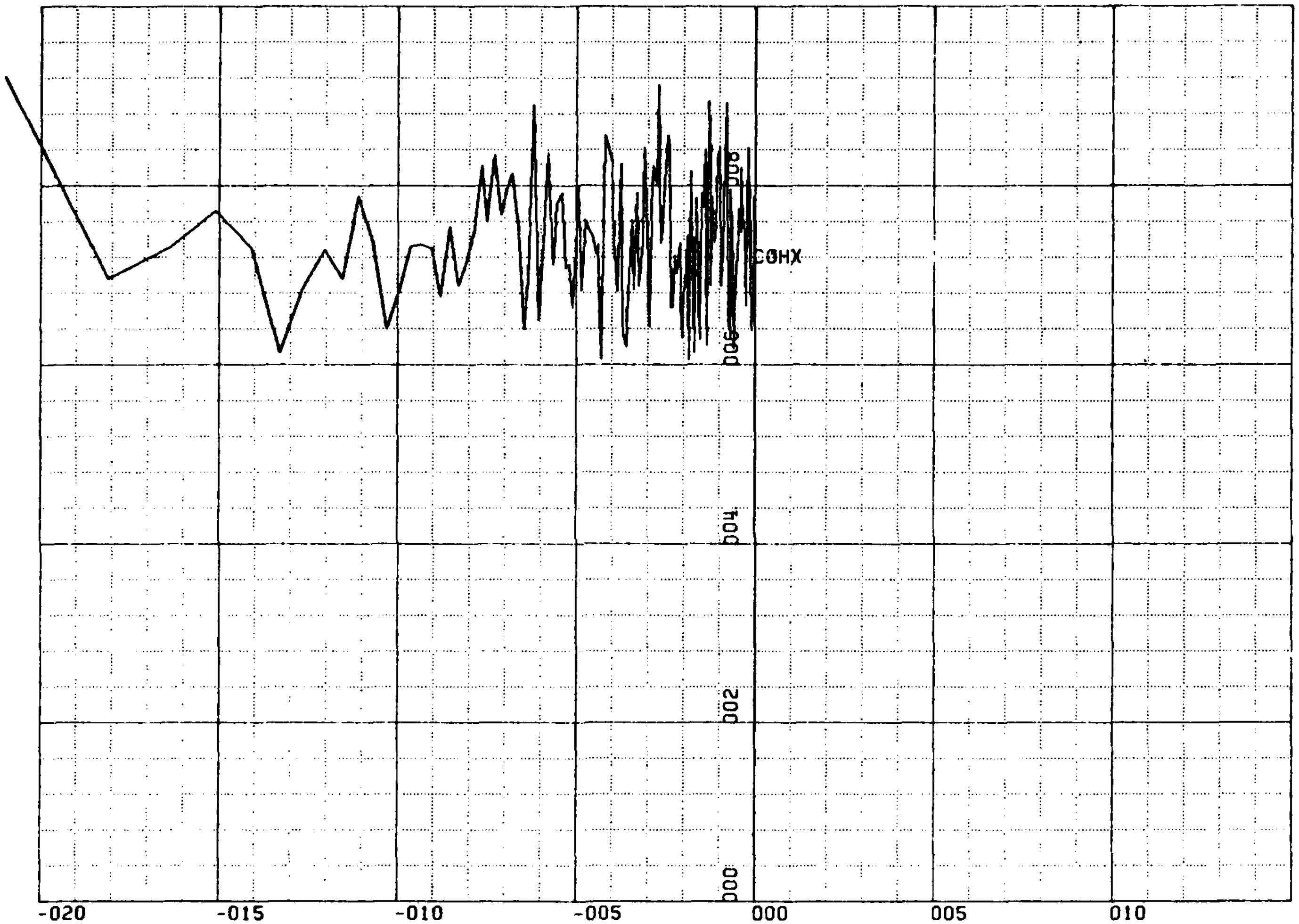


Figure 6.51 X Coil Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

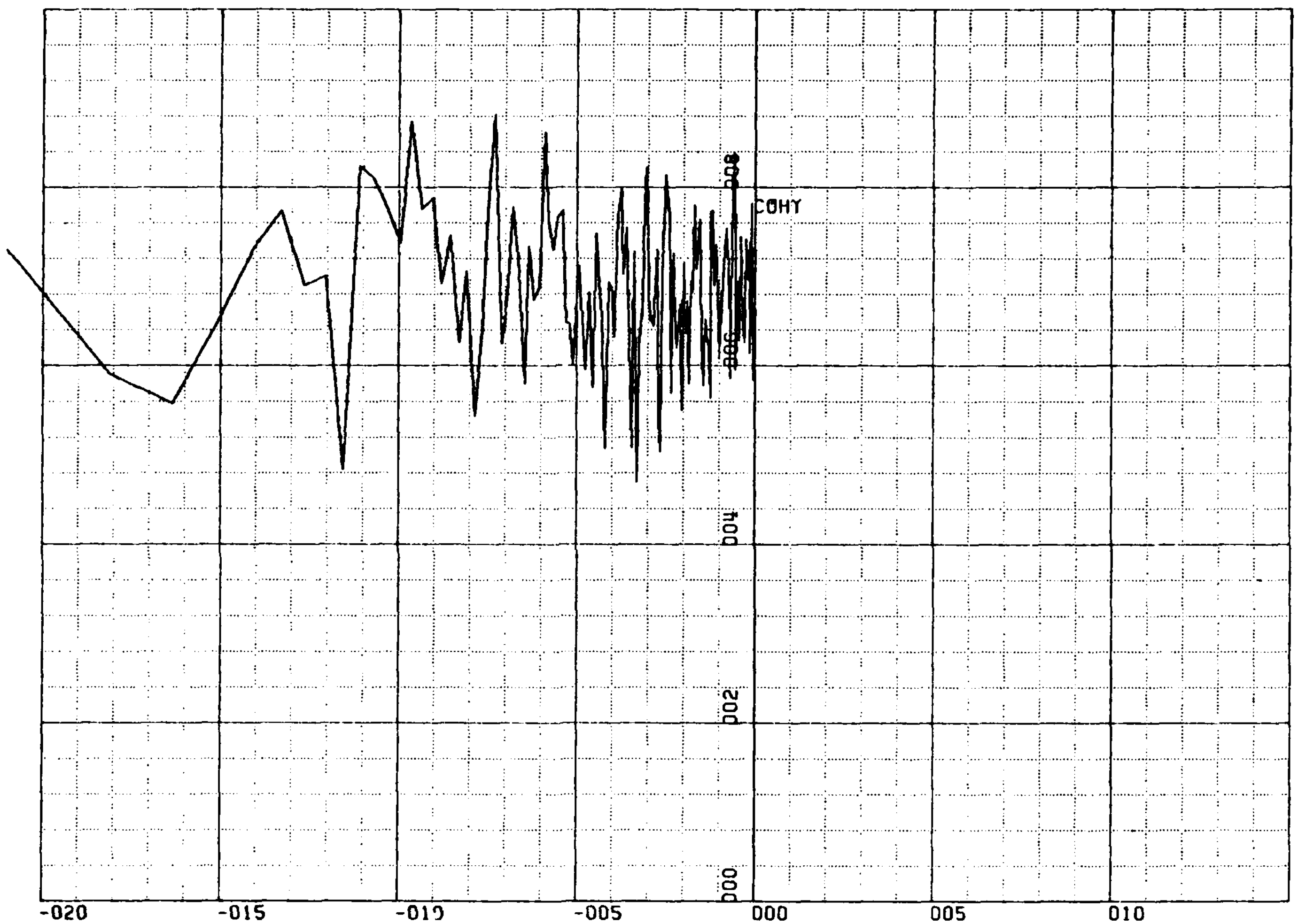


Figure 6.52 Y Coil Coherence
1500 - 1540 Local
Coherency (0.2 units/inch) vs Log Frequency (0.5 Log Hz/ inch).

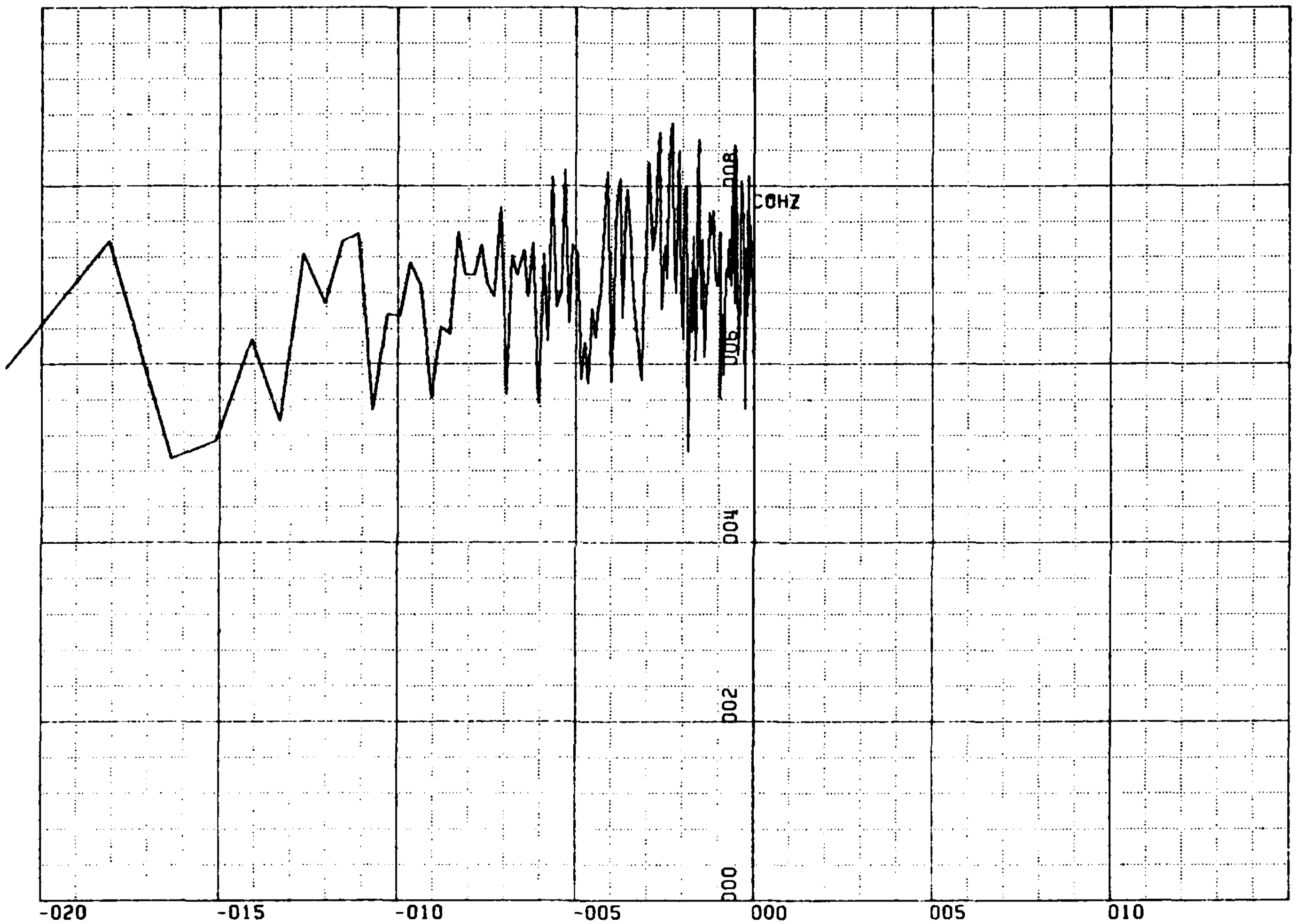


Figure 6.53 Z Coil Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/ inch).

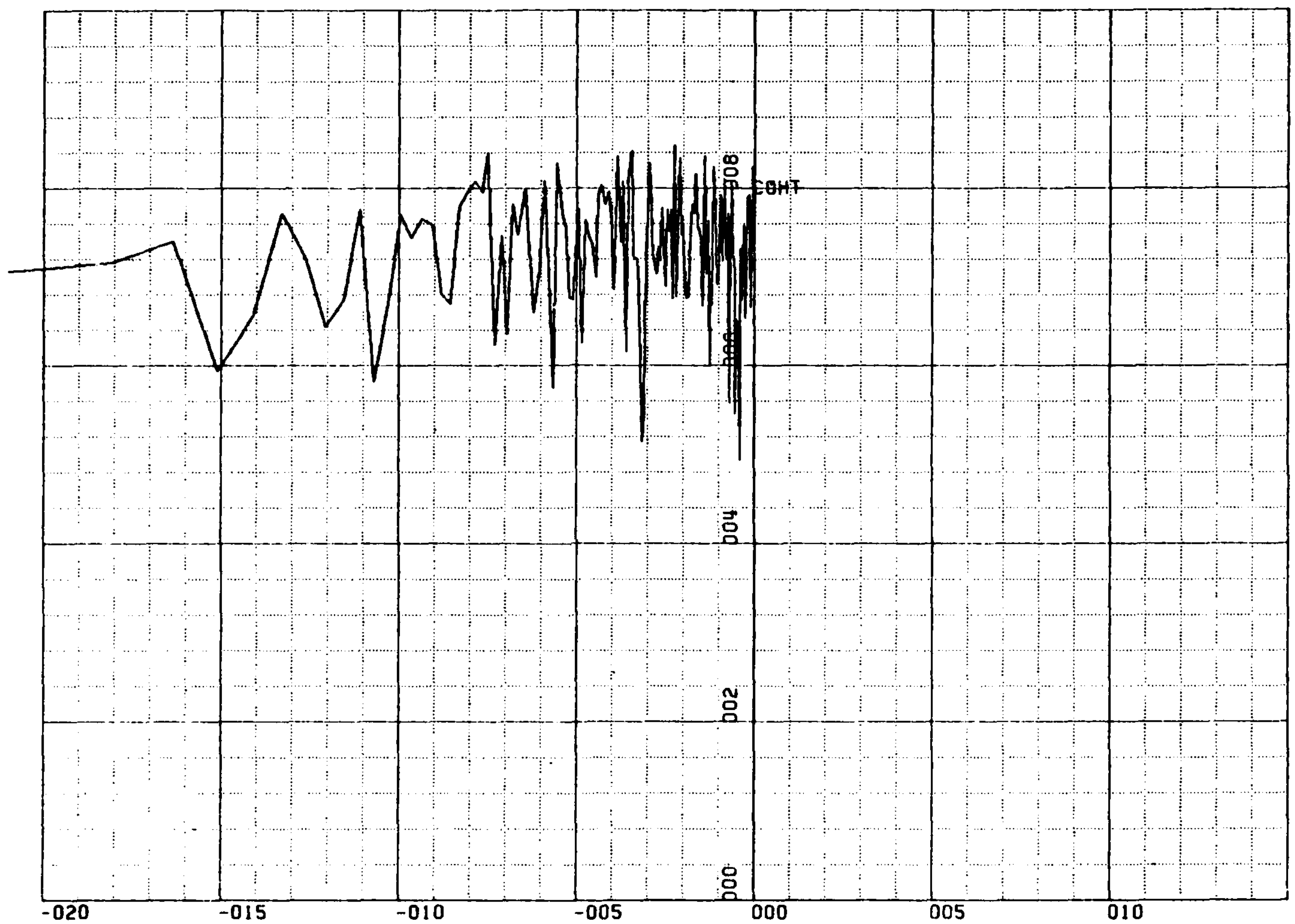


Figure 6.54 Total Field Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

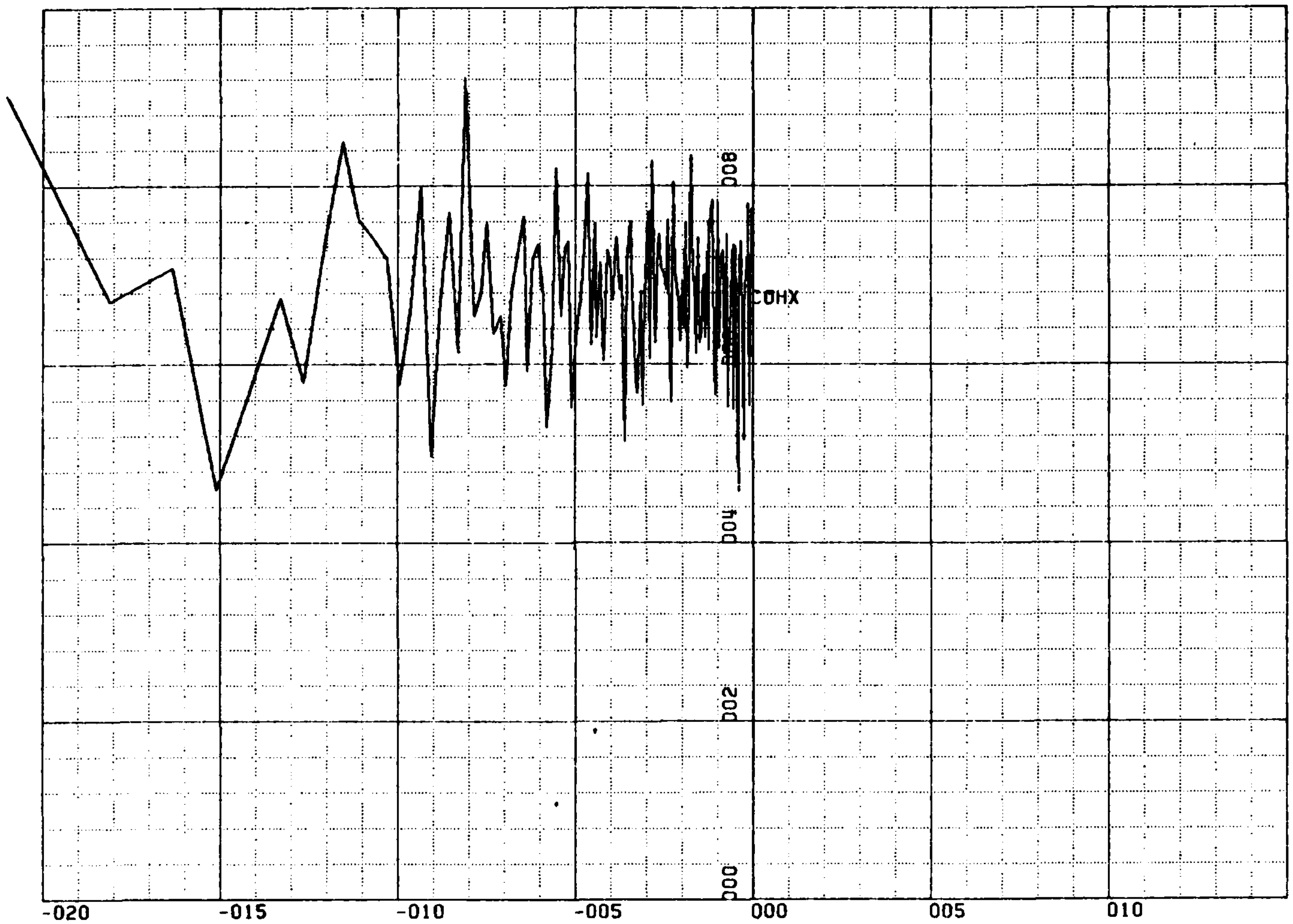


Figure 6.55 X Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

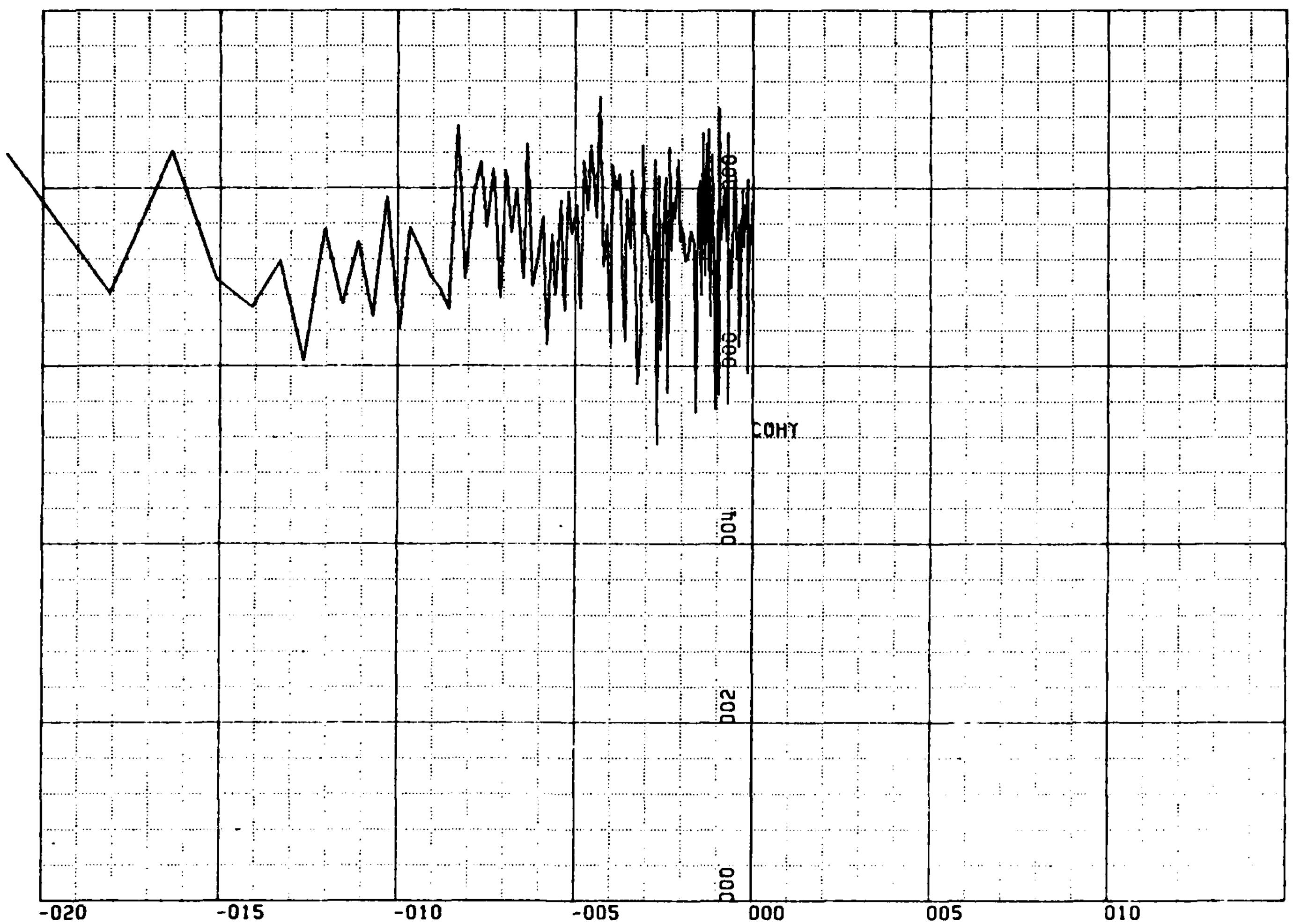


Figure 6.56 Y Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

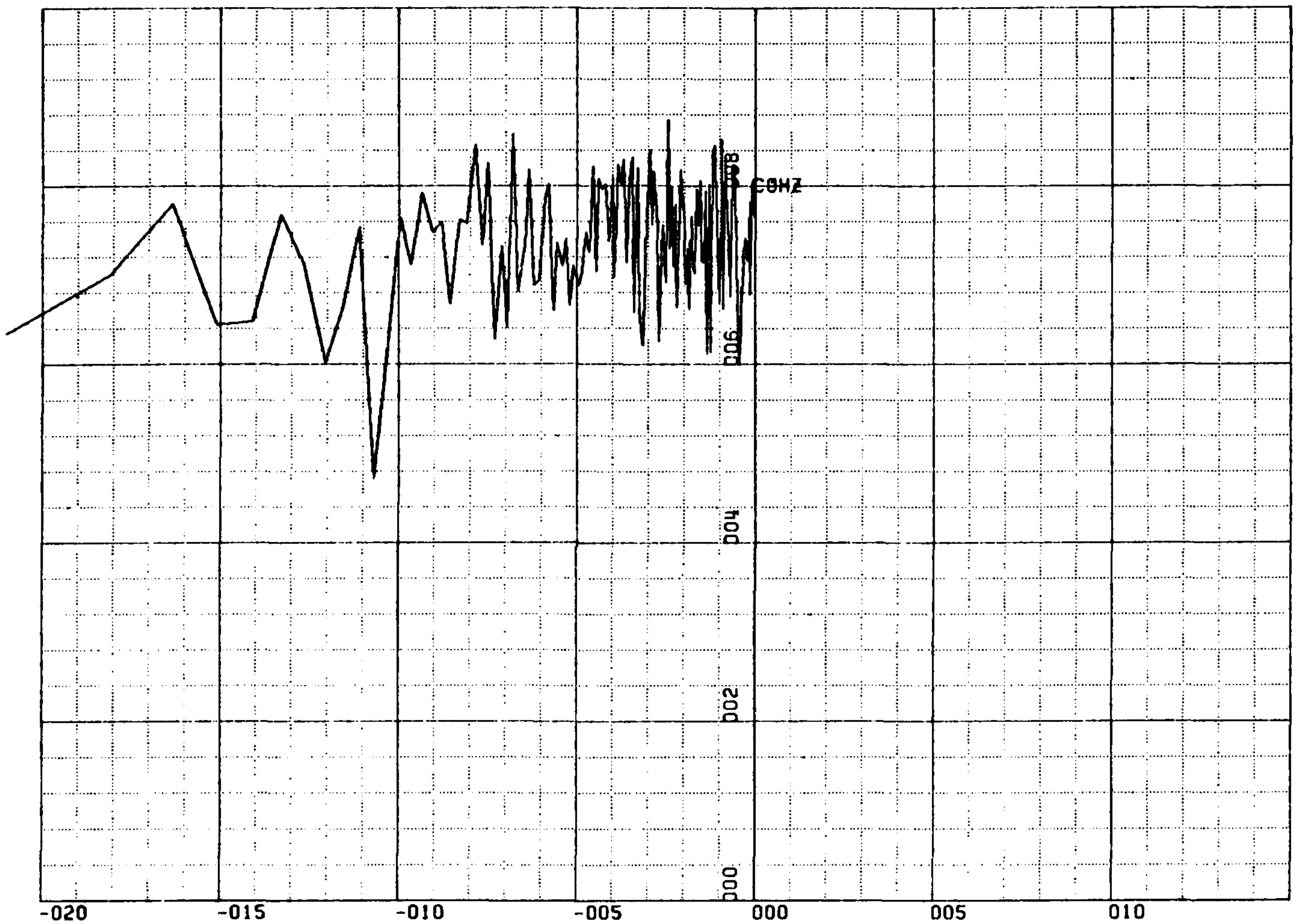


Figure 6.57   Z Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

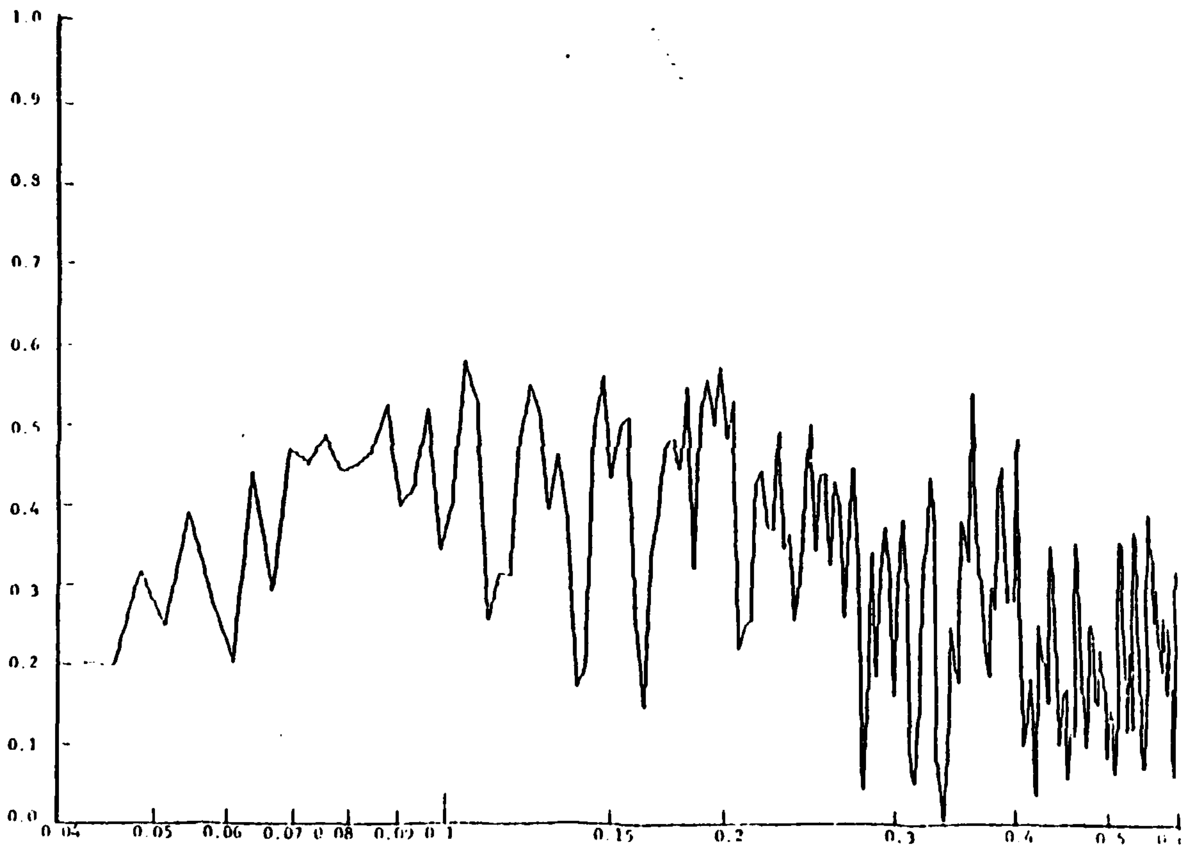


Figure 6.58 Total Field Coherence, NADC

11 July 1979, 1430 - 1630 Local

Coherence vs Frequency

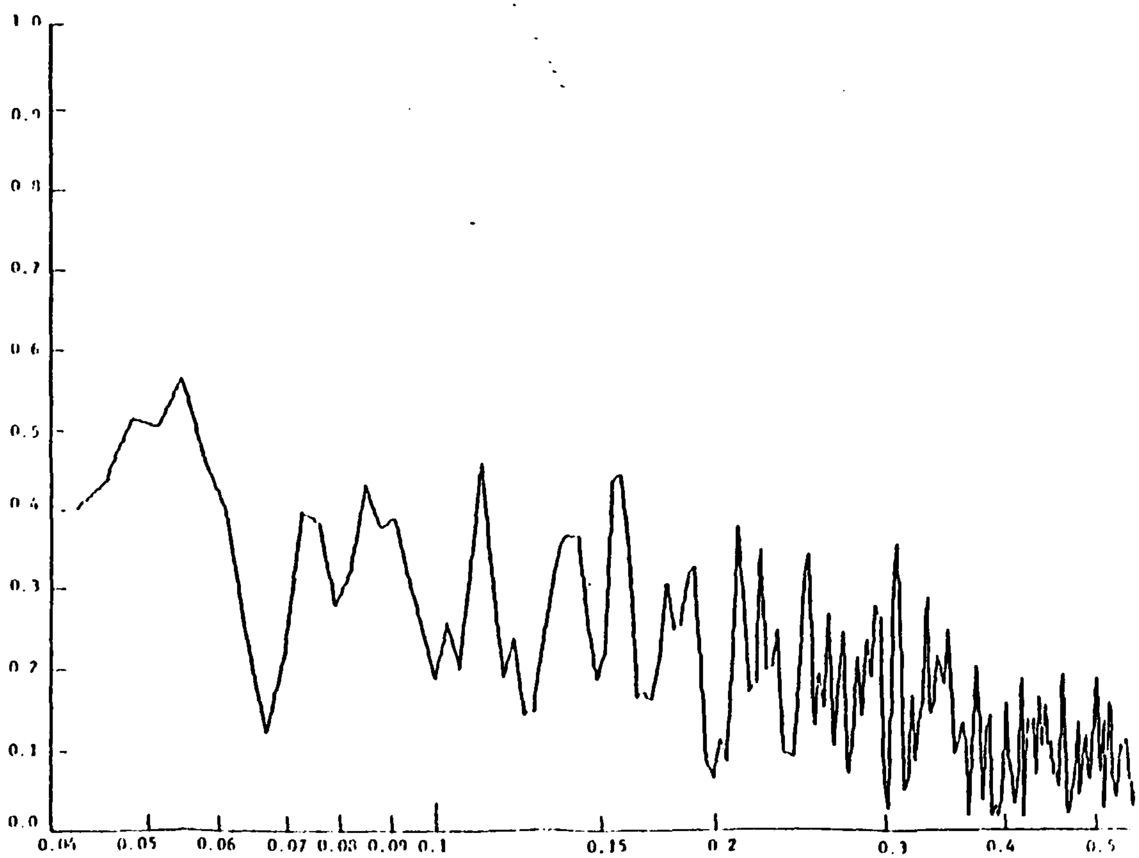


Figure 6.59 Total Field Coherence, NADC

11 July 1979, 1700 - 1900 Local

Coherence vs Frequency

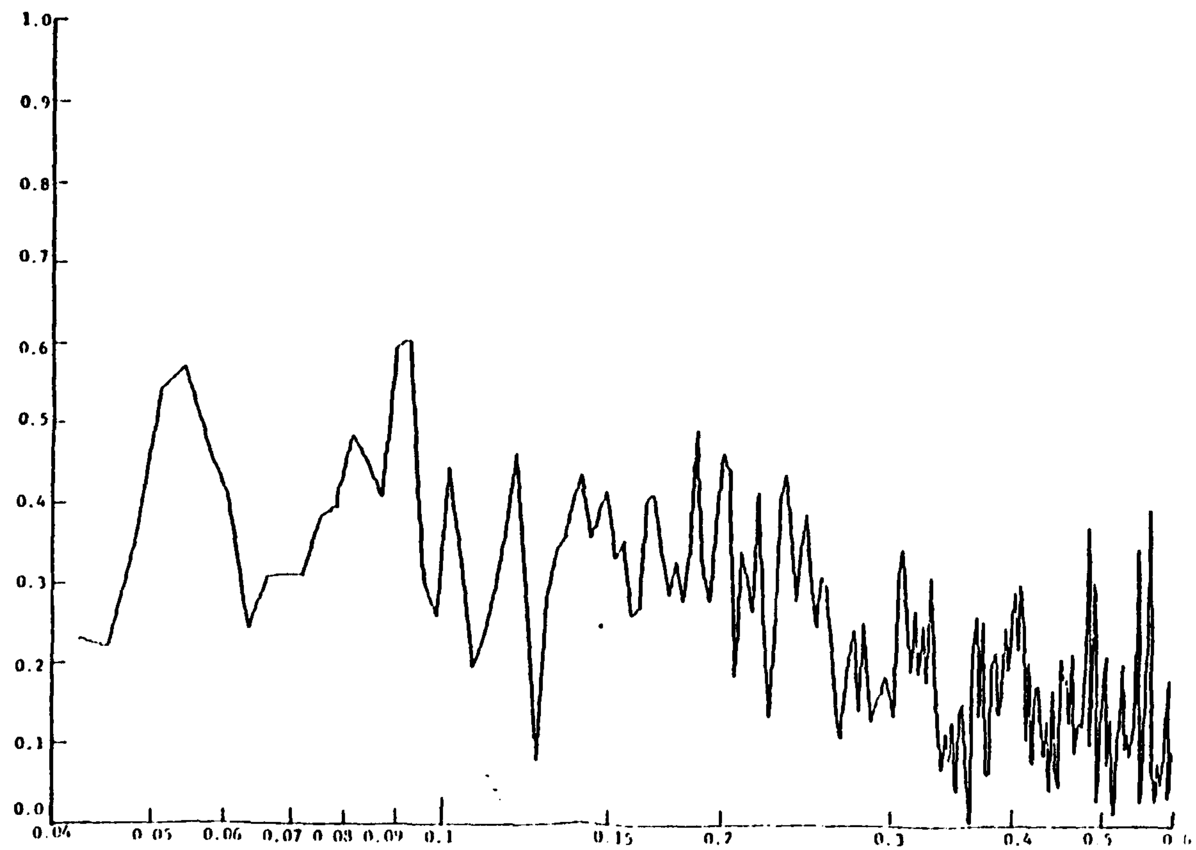


Figure 6.60 Total ˙ield Coherence, NADC

11 July 1979, 1915 - 2115 Local

Coherence vs Frequency

VII. CONCLUSIONS AND RECOMMENDATIONS

A coherence of 0.6 - 0.8 in the background component of the geomagnetic field between 0.04 and 0.6 Hz was established. A coherence in this range should be considered only moderate. A lack of high coherence (0.9 - 1) indicates that the variations in the background field observed at the earth's surface at the two sites are not produced directly by the same source. However, the variations are clearly not random in nature. The moderate coherences found suggest that the source mechanisms for the background component in the geomagnetic field are complex and involve mechanisms in addition to or intermediate to simple fluctuations in the interplanetary magnetic field.

A discernable micropulsation was not recorded during the five hours of data taken. It is recommended that additional data be taken at the two sites in the hope of performing a coherence study on the micropulsation component of the geomagnetic field. It is also recommended that data be taken at additional sites of greater separation (100 km or more) in order to investigate the degree of coherence with distance.

APPENDIX A

SITE DESCRIPTION

The Chew's Ridge fire lookout is located 40 km southeast of the Naval Postgraduate School and at an altitude of approximately 3900 feet above sea level. It was chosen for its remoteness from the local power grid. Since the site is within the Los Padres National Forest, permission to collect data there had to be obtained from the National Forest Service. A dirt road provides easy access to the site for the transporting of equipment. The Monterey Institute for Research in Astronomy is currently constructing an observatory approximately one half mile from the lookout. What affect its presence will have on the suitability of the fire lookout for future data collection is not currently known.

Initial attempts to transmit the PCM data via a 170 MHz carrier wave from this site to the school proved impossible due to the relatively low transmission power used (3 watts), less than ideal line of sight, less than ideal antenna.

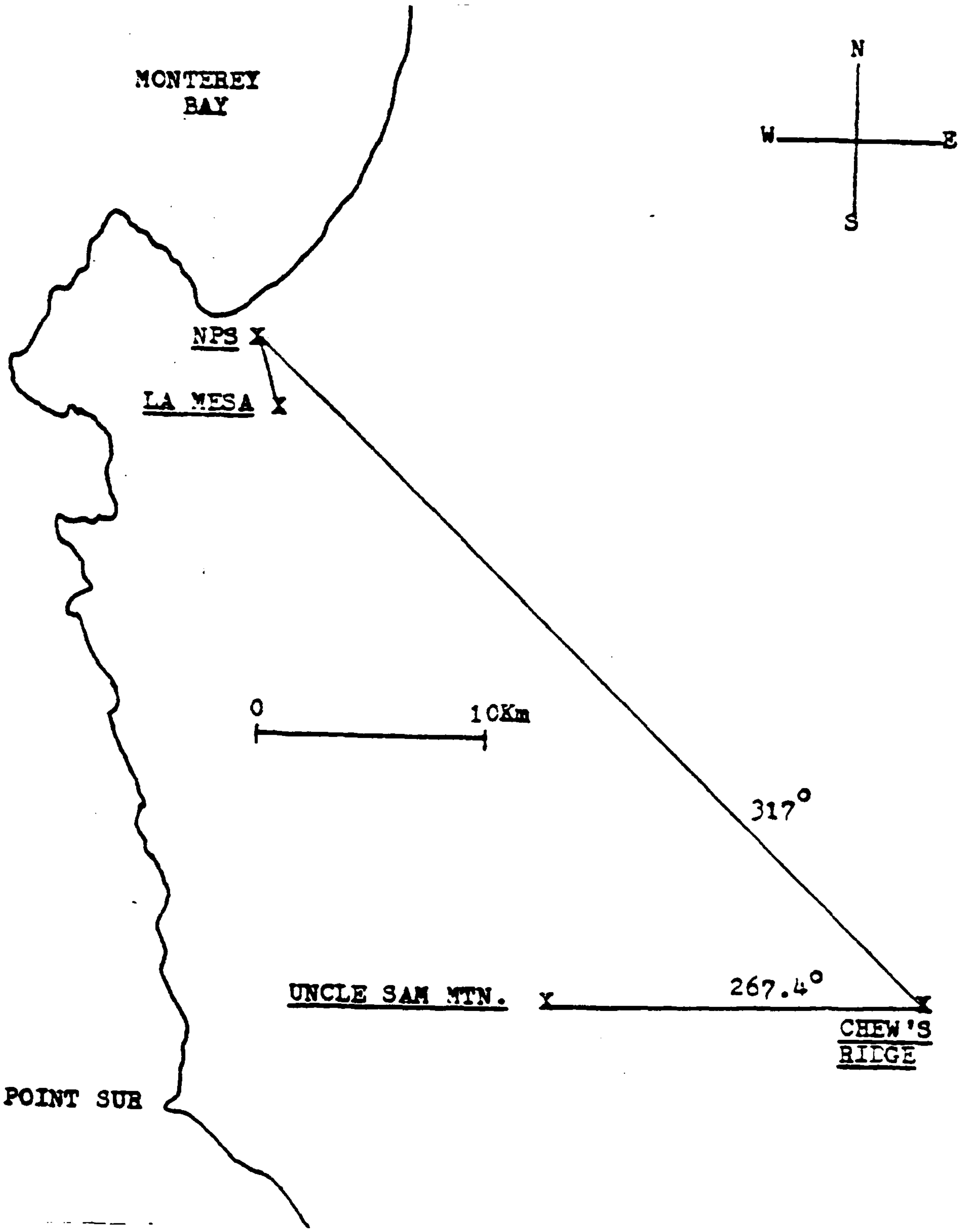


Figure A.1 Geographical Area of Data Collection.

APPENDIX B

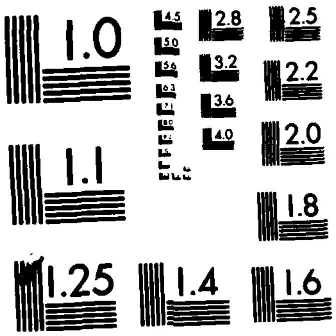
PCM DECODING PROCEDURE

Several electronic components are utilized to decode the PCM data to digital form which is ultimately stored on nine track, 800 bits per inch digital tape. This data processing system is shown in Figure B.1. Central control of this process is accomplished with a Hewlett Packard 9845A computer utilizing an operator interactive program, "PCMPROG". After execution of the program, the computer requests entry of specific function control parameters into the computer and other equipment. These inputs are used to control synchronization of equipment start, digital tape drive speed, decode rate, decode time and synchronization code word entry into the decoder. The PCM encoded data is fed into the system from the HP 3964A/3968A tape recorder previously used to record the data. The decoding of the PCM data is accomplished with a Marine Profiles, Incorporated Model 319 PCM decoder. A Monsanto AM-6419/USM-368 oscilloscopes are used to display the PCM data. A Kennedy Model 9800 digital recorder and computer interface are employed to store the digital data on the nine track digital tape.

AD-A138 542 COHERENCE STUDY OF GEOMAGNETIC FLUCTUATIONS IN FREQUENCY RANGE 04 - 06 HZ BETWEEN REMOTE LAND SITES (U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA S J ANTHONY 2/2

UNCLASSIFIED DEC 83 F/G 8/14 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

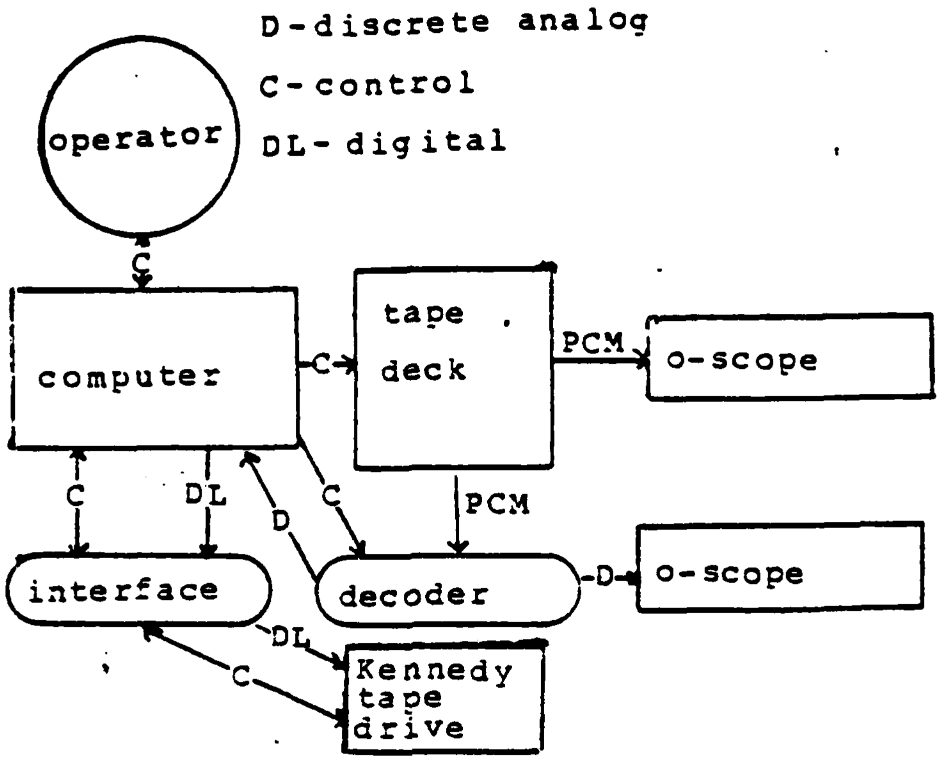


Figure B.1 Decoding System Data Flow and Control.

1. <u>Decoding Procedure</u>

a. Connect a coaxial cable between the output channel desired for decoding of the HP 3964A/3984A tape recorder and channel three of the Model 319 PCM decoder.

b. Energize the HP 3964A/3984A tape recorder, the Monsanto AM-6419/USM-368 oscilloscope, the Kennedy interface and the AANDERAA tape transfer interface, the Model 319 PCM decoder and the HP 9845A computer. Also, on the PCM Model 319 decoder place the fan toggle switch in the UP position and the AC/DC/OFF switch in the AC position.

c. Place into the right hand side tape reader of the HP 9845A computer the program named "PCM PROG". Type the command "MASS STORAGE IS":T15" and press EXECUTE. Then type the command GET "MT" and press EXECUTE.

d. On the PCM decoder place the following functions to the listed positions:

SOURCE - 3

SAMPLE RATE - 64 (for 3 3/4 recorder speed)

INVERT/NORMAL - NORMAL

OUTPUT/SAMPLE RATE - 0

RECORDS/FILE - INFINITY

SYNC CODE - 000

e. Press RUN on the computer, ignore the computer's response "enter Y to skip tape init" and press CONTINUE.

f. The computer now indicates "load tape" into the Kennedy unit and "put on line". To do this energize the Kennedy unit, place a write ring on the digital tape and load the tape according to the diagram located on the inside of the unit's door, press the LOAD button and the ON-LINE button located on the front of the unit.

g. The computer now indicates "enter synch code". Type into the computer 3658 (Chew's Ridge tapes) or 3155 (La Mesa Village tapes) and press CONTINUE.

h. Enter transfer time in minutes and seconds into the computer. For example 30 minutes and 50 seconds would be typed in as 30,50. Most analog tapes lasted 45 - 50 minutes. After this is done, press CONTINUE.

i. Push the STOP switch on the PCM decoder and press CONTINUE on the computer.

j. Push the PLAY button on the Hewlett Packard tape recorder, listening to the WWV time signal over a speaker or headphones. Push the START switch on the PCM decoder to begin the decoding process at a chosen time, using the second "ticks" of the time signal as a count-down. The decoding of the corresponding analog tape from the other recording site must be started at precisely the same time.

k. To end the data transfer early, push the K0 button on the computer. If this option is selected, "T" must be entered on the computer to write end of file on the digital tape.

l. "End of run" will be indicated on the computer CRT. Deenergize the equipment.

APPENDIX C

VOLTR COMPUTER PROGRAM

```
//CHFI1SR JOE (2952,0165),'ANTHONY    SMC 2123',CLASS=G
//*MAIN ORG=NPGVM1.2992P,LINES=(65)
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GC=2048K
//FORT.SYSIN DD *
C
C     THIS PROGRAM GENERATES ROUGH VOLTAGE VS TIME PLOTS. THE DATA IS
C     READ FROM A COMPUTER TAPE IN BLOCKS CONTAINING 8192 SAMPLES, OR
C     128 SECONDS, OF DATA.
      INTEGER*2 IN(16)
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE
      REAL*4 XX(8192),YY(8192),ZZ(8192)
C       THE ABOVE REAL*4 ARRAYS ARE USED TO ORDER INPUT DATA AND
C       INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.
      DIMENSION ZZX1(65536),ZZY1(65536),ZZV1(65536)
      DIMENSION TIME2(65536)
      INTEGER K,I5
      INTEGER*4 ITB(12)/12*0/
      REAL*4    RTB(28)/28*0.0/
      REAL ALAB(3)/'CH-X','CH-Y','CH-Z'/
      REAL*8 TITLE(12)
      EQUIVALENCE(TITLE(1),RTB(5))
C       ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING
C       THE VERTSATEC PLOTTER OUTPUT.
      DATA XX,YY/16384*0./
      DATA ZZ/8192*0./
      K=0
      I5=1
      DO 31 IN1=1,65536
      ZZX1(IN1)=0.0
      ZZY1(IN1)=0.0
      ZZV1(IN1)=0.0
      TIME2(IN1)=0.0
   31 CONTINUE
C        THE NEXT FIVE LINES SERVE AS A TIME DELAY IN STARTING THE
C        DATA ANALYSIS. ISEC IS THE NUMBER OF SECONDS DELAYED.
      ISEC=10
      ITL=ISEC*64
      DO 55 JJ=1,ITL
      CALL RC(20,IN,200,IREC,IRR)
   55 CONTINUE
      IFRAME=8192
C       THE VALUE OF NR DETERMINES THE NUMBER OF DATA BLOCKS THE ARE
C       READ AND ANALYZED.
      NR=8
      FNR=FLOAT(NR)
      DO 70 L1=1,NR
C       THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO
```

```
C        PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN
C        BLOCKS.
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES. ONE
C        SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL
C        OR 128 SECONDS OF DATA.
C
C         THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME
C         STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL
C         CHANNEL.
      DO 60 JJ=1,IFRAME
      CALL RD(20,IN,1000,IREC,IRR)
      XX(JJ)=IN(2)
      YY(JJ)=IN(3)
      ZZ(JJ)=IN(4)
   60 CONTINUE
      N=8192
      FN=FLOAT(N)
      DELTAT=1./64.
      DO 20 J=1,N
C     THE FOLLOWING CALCULATIONS NORMALIZE THE DATA TO +5V AND -5V.
      XX(J)=((XX(J)-2048.)*5./2048.)
      YY(J)=((YY(J)-2048.)*5./2048.)
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)
C        'XX' IS THE X-COIL DATA, 'YY' IS THE Y-COIL DATA,
C        'ZZ' IS THE Z-COIL DATA
C         NORTH-SOUTH COMPONENT (XX) AND THE VERTICAL COMPONENT (ZZ)
   20 CONTINUE
C         THE FOLLOWING LOOP PUTS THE DATA FROM EACH 8192-SAMPLE ARRAY
C         INTO ONE CONTINUOUS NR*8192 SAMPLE ARRAY
      DO 91 I3=1,8192
      ZZX1(I5)=XX(I3)
      ZZY1(I5)=YY(I3)
      ZZV1(I5)=ZZ(I3)
      TIME2(I5)=(DELTAT*FLOAT(I3))+(128.0*FLOAT(K))
      I5=I5+1
   91 CONTINUE
      K=K+1
   70 CONTINUE
C
C     VERSATEC PLOT OF V - TIME SERIES VOLTAGE
C
      NPTS=1020./DELTAT +1.
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN ORDER FOR
C         THE 0 TO NPTS  SECS RANGE TO BE PLOTTED.
C        FOR THE FOLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP
C        FOR THE SUBROUTINE PROCEDURE 'DRAWP'.
      ITB(3)=20
      ITB(4)=8
```

```
      ITB(7)=1
      ITB(12)=0
      RTB(1)=0.0
      RTB(2)=0.0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
      ITB(3)=7
      ITB(4)=5
      ITB(12)=0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
 3000 FORMAT(6A8)
      STOP
      END
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)
C
C         THIS PROCEDURE FURNISHED BY DR. TIM  STANTON,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C               READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C       IUN=TAPE NUMBER, EG 20
C       IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5
C                /2028.  GIVES VOLTAGE
C       IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C       IREC= COUNTER OF RECORDS (FRAMES OF DATA)
C           BLOCK 512 BITS,   32 BITS = RECORD
C           800 BPI TAPE UNLABLED
C       IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       DATA IRR /0/
       IF (IREC.EQ.0) IS=0
```

```
      IER=0                                                             VOLO1450
 20   FORMAT (16A2)                                                     VOLO1460
      IF (IS.NE.0) GO TC 50                                             VOLO1470
      READ (IUN,20,END=900) IP                                          VOLO1480
      IREC=IREC+1                                                       VOLO1490
 40   IS=IS+1                                                           VOLO1500
      IF (IS.LT.17) GO TO 50                                            VOLO1510
      READ (IUN,20,END=900) IP                                          VOLO1520
     IS=1                                                               VOLO1530
     IREC=IREC+1                                                        VOLO1540
 50  ICH=IMASK(IF(IS),3,0)+1                                            VOLO1550
C     WRITE (6,55) ICH,IS,IUN,IREC                                      VOLO1560
 55   FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)                       VOLO1570
C                                                                       VOLO1580
     IF (ICH.NE.1) GO TO 40                                             VOLO1590
     DC 100 I=1,16                                                      VOLO1600
      IO(I)=ISHIFT(IP(IS),4)                                            VOLO1610
     ICH=IMASK(IP(IS),3,0)+1                                            VOLO1620
     IF (ICH.EQ.1) GO TO 80                                             VOLO163C
     IER=IER+1                                                          VOLO1640
     WRITE (6,70)  IUN,IREC ,I,ICH,IER                                  VOLO1650
 7C   FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,          VOLO1660
    $ 'ERRORS ',I7)                                                     VOLO1670
 80   IS=IS+1                                                           VOLO1680
      IF (IS.LT.17) GO TO 100                                           VOLO1690
      READ (IUN,20,END=9CC) IP                                          VOLO1700
      IS=1                                                              VOLO1710
      IREC=IREC+1                                                       VOLO1720
 100  CONTINUE                                                          VOLO1730
C                                                                       VOLO1740
      IF (IER.EC.0) GO TO 150                                           VOLO1750
      IRR=IRR+1                                                         VOLO1760
      IF (IRR.LT.IRS) GC TO 120                                         VOLO1770
      WRITE (6,110)                                                     VOLO1780
 110  FORMAT ('1 STCPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L11C')   VOLO1790
      IRQ=IRR                                                           VOLO1800
      STOP                                                              VOLO1810
 120  CONTINUE                                                          VOLO1820
      WRITE (6,130) IREC,IRR                                            VOLO1830
 130  FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)          VOLO1840
      IER=0                                                             VOLO1850
      IRQ=IRR                                                           VOLO1860
      GO TO 50                                                          VOLO1870
 150  CONTINUE                                                          VOLO1880
      RETURN                                                            VOLO1890
 900  WRITE (6,910) IUN,IREC                                            VOLO1900
 910  FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)                      VOLO1910
      STOP                                                              VOLO1920
```

```
      END
      FUNCTION ISHIFT (IN,NPLC)
C              RETURNS SHIFTED VALUE OF I*2 WORD IN
C              -VE LEFT,+VE RIGHT SHIFT
C
      INTEGER * 2 IN
      IP=IN
      IF (IP.LT.0) IP=IP+65536
      IF (NPLC.LT.0) GO TO 30
      ISHIFT=IP/(2**IABS(NPLC))
      RETURN
 30   ISHIFT=IP*(2**IABS(NPLC))
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
      RETURN
      END
      FUNCTION IMASK (IN,IBL,IBR)
C              MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
      INTEGER * 2 IN,IO
      IO=IN
      IF (IBR.EQ.0) GO TO 50
      IT=ISHIFT(IN,IBR)
      IO=IT
 50   IP=ISHIFT(IO,IBL-15-IBR)
      IO=IP
      IMASK=ISHIFT(IO,15-IBL)
      RETURN
      END
/*
//GO.SYSIN DD *
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
X COIL AMP IN VOLTS
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
Y COIL AMP IN VOLTS
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
Z COIL AMP IN VOLTS
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
X COIL AMP IN VOLTS
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
Y COIL AMP IN VOLTS
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL
Z COIL AMP IN VOLTS
/*
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=CRDT3A,DISP=(OLD,KEEP),
//             LABEL=(1,NL,,IN),
//             DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)
//GO.SYSDUMP DD SYSOUT=A
```

VOLO 2410
VOLO 2420

APPENDIX D

VODIG COMPUTER PROGRAM

```
//CHFI23S JOB (2992,0165),'ANTHONY   SMC 2123',CLASS=G
//*MAIN ORG=NPGVM1.2992P,LINES=(75)
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K
//FORT.SYSIN DD *
C        THIS PROGRAM READS IN DATA FROM DIGITAL TAPES USING THE
C     SUBROUTINE RD, NORMALIZES THE DATA BETWEEN -5 AND +5 VOLTS, APPLIES
C     A DIGITAL BANDPASS FILTER BETWEEN .04 AND .6 HZ DEVELOPED BY MIKE
C     HLETE AND THEN PUTS THE DATA THROUGH A 144 POINT DOUBLE RUNNING
C     AVERAGE SMOOTHING ROUTINE.
C
      INTEGER*2 IN(16)
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE
      REAL*8 XX(8196),YY(8196),ZZ(8196),XXS(8196),YYS(8196),ZZS(8196)
      REAL*8 FIX(18),FOX(18),FIY(18),FOY(18),FIZ(18),FOZ(18)
C       THE ABOVE REAL*8 ARRAYS ARE USED TO ORDER INPUT DATA AND
C       INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.
      DIMENSION ZZX1(65568),ZZY1(65568),ZZV1(65568)
      DIMENSION TIME2(65568)
      DATA FIX,FIY/36*0./
      DATA FIZ/18*0./
      INTEGER K,C,I5,I4
      REAL SUMX,SUMY,SUMZ,SUMT,AVE1,AVE2,AVE3,AVE4
      INTEGER*4  ITB(12)/12*0/
      REAL*4     RTB(28)/28*0.0/
      REAL ALAB(4)/'CH-X','CH-Y','CH-Z','TOT'/
      REAL*8 TITLE(12)
      EQUIVALENCE(TITLE(1),RTB(5))
C       ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING
C       THE VERTSATEC PLOTTER OUTPUT.
      DATA XX,YY/16392*0./
      DATA ZZ/8196*0./
      K=0
      I5=5
      I6=1
C    THE FOLLOWING LOOP ADVANCES THE DIGITAL TAPE BY ISEC SECONDS.
C
      ISEC=1940
      ITL=ISEC*64
      DO 55 JJ=1,ITL
      CALL RD(20,IN,200,IREC,IRR)
   55 CONTINUE
      IFRAME=8196
      NR=3
      FNR=FLOAT(NR)
      DO 70 L1=1,NR
C       THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO
C       PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN
```

```
C        BLOCKS.
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES.
C        1 SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL
C        OR 128 SECONDS OF DATA.
C
C         THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME
C         STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL
C         CHANNEL
      DO 60 JJ=5,IFRAME
      CALL RD(20,IN,1000,IREC,IRR)
   58 XX(JJ)=IN(2)
      YY(JJ)=IN(3)
      ZZ(JJ)=IN(4)
   60 CONTINUE
      N=8196
      FN=FLOAT(N)
      DELTAT=1./64.
C     NORMALIZE THE DATA BETWEEN +5 AND -5 VOLTS.  FOR LAMESA DATA,
C     SUBTRACT 1.36, 1.0 AND 1.0 FROM XX, YY AND ZZ RESPECTIVELY, TO
C     REMOVE DC COMPONENT.
      DO 20 J=5,N
      XX(J)=((XX(J)-2048.)*5./2048.)
      YY(J)=((YY(J)-2048.)*5./2048.)
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)
C        'XX' IS THE X-COIL DATA, 'YY' IS THE Y-COIL DATA,
C        'ZZ' IS THE Z-COIL DATA
C        NORTH-SOUTH COMPONENT (XX) AND THE VERTICAL COMPONENT (ZZ)
   20 CONTINUE
      DO 91 I3=5,8196
      ZZX1(I5)=XX(I3)
      ZZY1(I5)=YY(I3)
      ZZV1(I5)=ZZ(I3)
      I5=I5+1
   91 CONTINUE
   70 CONTINUE
C     DOUBLE RUNNING POINT AVERAGE
      DO 73 L2=1,2
      Q=0
      DO 74 IS=5,65423
      SUMX=0.0
      SUMY=0.0
      SUMZ=0.0
      DO 75 J=5,149
      SUMX=ZZX1(Q+J)+SUMX
      SUMY=ZZY1(Q+J)+SUMY
      SUMZ=ZZV1(Q+J)+SUMZ
   75 CONTINUE
      ZZX1(IS)=SUMX/144.
```

```
      ZZY1(IS)=SLMY/144.
      ZZV1(IS)=SLMZ/144.
      Q=Q+1
   74 CCNTINUE
   73 CCNTINUE
C     APPLY CIGITAL FILTER TO DATA BLOCK
      K2=5
      DC 92 M1=1,NR
      DC 100 K1=5,8196
      XX(K1)=ZZX1(K2)
      YY(K1)=ZZY1(K2)
      ZZ(K1)=ZZV1(K2)
      K2=K2+1
  10C CCNTINUE
      CALL  DIGFIL(XX,FIX,XXS,FOX)
      CALL  DIGFIL(YY,FIY,YYS,FOY)
      CALL  DIGFIL(ZZ,FIZ,ZZS,FOZ)
      DC 21  L=1,18
      FIX(L)=FOX(L)
      FIY(L)=FOY(L)
      FIZ(L)=FOZ(L)
   21 CCNTINUE
      I4=1
      DC 90  I3=5,8196
      ZZX1(I6)=XXS(I3)
      ZZY1(I6)=YYS(I3)
      ZZV1(I6)=ZZS(I3)
      TIME2(I6)=(CELTAT*FLOAT(I4))+(128.0*FLOAT(K))
      I4=I4+1
      I6=I6+1
   90 CCNTINUE
      K=K+1
   92 CCNTINUE
      NL=8192*NR-1280
      DC 98  I7=1,NL
      ZZX1(I7)=ZZX1(I7+128C)
      ZZY1(I7)=ZZY1(I7+1280)
      ZZV1(I7)=ZZV1(I7+1280)
   98 CCNTINUE
C
C    VERSATEC PLOT OF V - TIME SERIES VOLTAGE SMCCTHEC
C
      NPTS=380./CELTAT +1.
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN CRDER FOR
C          THE 0 TC NPTS  SECS RANGE TO BE PLOTTED.
C       FOR THE FCLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP
C       FOR THE SLBROUTINE PROCEDURE 'DRAWP'.
      ITB(3)=20
```

```
      ITB(4)=8
      ITB(7)=1
      ITB(12)=0
      RTB(1)=0.0
      RTB(2)=0.0
      RTB(3)=ALAE(1)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAE(2)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAE(3)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
      ITB(3)=7
      ITB(4)=5
      ITB(12)=0
      RTB(3)=ALAE(1)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAE(2)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAE(3)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
 3000 FORMAT(6A8)
      STOP
      END
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)
C
C         THIS PROCEDURE FURNISHED BY DR. TIM STANTON,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C        IUN=TAPE NUMBER, EG 20
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5
C              /2028.  GIVES VOLTAGE
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C        IREC= COUNTER OF RECORDS (FRAMES OF DATA)
C            BLOCK 512 BITS,   32 BITS = RECORD
C            800 BPI TAPE UNLABLED
C        IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       DATA IRR /0/
```

```
      IF (IREC.EC.0) IS=0
      IER=0
20    FORMAT (16A2)
      IF (IS.NE.0) GO TC 50
      READ (IUN,20,END=90C) IP
      IREC=IREC+1
40    IS=IS+1
      IF (IS.LT.17) GO TO 50
      READ (IUN,20,END=9C0) IP
     IS=1
     IREC=IREC+1
50   ICH=IMASK(IP(IS),3,0)+1
C     WRITE (6,55) ICH,IS,ILN,IREC
55    FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)
C
     IF (ICH.NE.1) GO TO 40
     CC 100 I=1,16
      IO(I)=ISHIFT(IP(IS),4)
     ICH=IMASK(IP(IS),3,0)+1
     IF (ICH.EQ.1) GO TO 80
     IER=IER+1
     WRITE (6,7C)  IUN,IREC ,I,ICH,IER
7C    FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,
    $ 'ERRORS ',I7)
80    IS=IS+1
      IF (IS.LT.17) GO TC 100
      READ (IUN,20,END=9CC) IP
      IS=1
      IREC=IREC+1
100   CONTINUE
C
      IF (IER.EC.0) GO TO 150
      IRR=IRR+1
      IF (IRR.LT.IRS) GO TO 120
      WRITE (6,110)
110   FORMAT ('1 STCPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L11C')
      IRQ=IRR
      STOP
120   CONTINUE
      WRITE (6,130) IREC,IRR
130   FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)
      IER=0
      IRQ=IRR
      GO TO 50
150   CONTINUE
      RETURN
900   WRITE (6,910) IUN,IREC
910   FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)
```

```
      STOP
      END
C
      SLBROUTINE CIGFIL(INFLD,FILE,SIG,FOLE)
C      THE ABOVE REAL*4 ARRAYS ARE USED TO ORDER INPUT DATA AND
C      INITIALLY FEPRESENT VOLTAGE - TIME SERIES INFCRMATICN.
      REAL*8 INFLC(8196),OUTFLD(8196),SIG(8196)
      REAL*8 YO(8196),YPO(8196),FILE(18),FOLE(18)
      REAL*8 XI(8196),XII(8196),XIII(8196),XIV(8196),XV(8196)
      CATA XI,XII/16392*0./
      CATA XIII,XIV/16392*0./
      CATA XV,YO/16392*0./
      CATA YPO/8196*0./
      CATA OUTFLD/8196*0./
      INTEGER K9
C
C     THE COMPLEX*8 ARRAYS ARE USED TO ORDER INPLT CATA ANC REPRESENT
C     VCLTAGE-TIME SERIES INFORMATICN.
C
      REAL*8 T,AFHP1,AFHP2,BFHPO,BFHP1,BFHP2,A,B,C,D,E,F,A1
      REAL*8 B1,C1,D1,E1,F1,G1,H1,I1,J1,K1,L1
      REAL*8 AA,BB,CC,DD,EE,FF,AA1,BB1,CC1,DD1,EE1,FF1,GG1,HH1,II1
      REAL*8 JJ1,KK1,LL1
      REAL*8 ASHP41,ASHP42,ASHP43,ASHP44,ASHP45,ASHP46,ASHP47
      REAL*8 ASLP61,ASLP62,ASLP63,ASLP64
      REAL*8 BSLP60,BSLP61,BSLP62,BSLP63,BSLP64
C
C     CEFINE AND COMPUTE ALL COEFFICIENTS
C
      T=1./64.
C
C     CCEFFICIENTS FCR FIXEC HIGH PASS FILTER
C
      AFHP1=-((T**2/160.-2.)/(1.+T/8.+T**2/320.))
      AFHP2=-((1.-T/8.+T**2/320.)/(1.+T/8.+T**2/320.))
      BFHPO=(1./(1.+T/8.+T**2/320.))
      BFHP1=-(2./(1.+T/8.+T**2/320.))
      BFHP2=(1./(1.+T/8.+T**2/320.))
C
C     CCEFFICIENTS FOR SELECTIVE HIGH PASS FILTER
C     IN THIS CASE,   FREQ(LOWER)=0.04 HZ
C
      A=12.52096/40.82834
      B=1./40.82834
      C=11.00999/45.28317
      D=1./45.28317
      E=7.41498/57.57668
      F=1./57.57668
```

```
      A1=1.+A*T/2.+B*(T**2)/4.                                          VODO2890
      B1=-2.+B*(T**2/2.)                                                VODO2900
      C1=1.-A*T/2.+B*(T**2)/4.                                          VODO2910
      D1=1.+C*T/2.+D*(T**2)/4.                                          VODO2920
      E1=-2.+D*(T**2)/2.                                                VODO2930
      F1=1.-C*T/2.+D*(T**2)/4.                                          VODO2940
      G1=1.+E*T/2.+F*(T**2)/4.                                          VODO2950
      H1=-2.+F*(T**2)/2.                                                VODO2960
      I1=1.-E*T/2.+F*(T**2)/4.                                          VODO2970
C                                                                       VODO2980
C     CODE IS "ASHP41" MEANS "A1 COEFFICIENT FOR THE SELECTABLE HIGH    VODO2990
C     PASS FILTER WITH LOWER LIMIT 0.04 HZ"                             VODO3000
C                                                                       VODO3010
      ASHP41=1./(A1*D1*G1)                                              VODO3020
      ASHP42=-(C1/A1)                                                   VODO3030
      ASHP43=-(B1/A1)                                                   VODO3040
      ASHP44=-(E1/D1)                                                   VODO3050
      ASHP45=-(F1/D1)                                                   VODO3060
      ASHP46=-(H1/G1)                                                   VODO3070
      ASHP47=-(I1/G1)                                                   VODO3080
C                                                                       VODO3090
C     COEFFICIENTS FOR SELECTABLE LOW PASS FILTER WITH UPPER FREQ       VODO3100
C     OF 0.6 HZ                                                         VODO3110
C                                                                       VODO3120
      A=1./0.03492                                                      VODO3130
      B=0.35804/0.03492                                                 VODO3140
      C=1./0.03492                                                      VODO3150
      D=1./0.02779                                                      VODO3160
      E=0.20696/0.02779                                                 VODO3170
      F=1./0.02779                                                      VODO3180
      A1=A*(T**2)/4.                                                    VODO3190
      B1=2.*A1                                                          VODO3200
      C1=A1                                                             VODO3210
      D1=D*(T**2)/4.                                                    VODO3220
      E1=2.*D1                                                          VODO3230
      F1=D1                                                             VODO3240
      G1=(1.+B*T/2.+C*(T**2)/4.)                                        VODO3250
      H1=(-2.+C*(T**2)/2.)                                              VODO3260
      I1=(1.-B*T/2.+C*(T**2)/4.)                                        VODO3270
      J1=(1.+E*T/2.+F*(T**2)/4.)                                        VODO3280
      K1=(-2.+F*(T**2)/2.)                                              VODO3290
      L1=(1.-E*T/2.+F*(T**2)/4.)                                        VODO3300
      ASLP61=-(G1*K1+H1*J1)/(G1*J1)                                     VODO3310
      ASLP62=-(G1*L1+H1*K1+I1*J1)/(G1*J1)                               VODO3320
      ASLP63=-(H1*L1+I1*K1)/(G1*J1)                                     VODO3330
      ASLP64=-(I1*L1)/(G1*J1)                                           VODO3340
      BSLP60=(A1*C1)/(G1*J1)                                            VODO3350
      BSLP61=(A1*E1+B1*C1)/(G1*J1)                                      VODO3360
```

```
      BSLP62=(A1*F1+B1*E1+C1*D1)/(G1*J1)
      BSLP63=(B1*F1+C1*E1)/(G1*J1)
      BSLP64=(C1*F1)/(G1*J1)
C
C     SET TRANSFERED VALUES EQUAL TO INTIIAL ARRAY VALUES AND
C     APPLY DIGITAL FILTER TO ARRAY INFLD
      YO(4)=FILE(1)
      YO(3)=FILE(2)
      XI(4)=FILE(3)
      XI(3)=FILE(4)
      XIII(4)=FILE(5)
      XIII(3)=FILE(6)
      XV(4)=FILE(7)
      XV(3)=FILE(8)
      YPO(4)=FILE(9)
      YPO(3)=FILE(10)
      YPO(2)=FILE(11)
      YPO(1)=FILE(12)
      OUTFLD(4)=FILE(13)
      OUTFLD(3)=FILE(14)
      OUTFLD(2)=FILE(15)
      OUTFLD(1)=FILE(16)
      INFLD(4)=FILE(17)
      INFLD(3)=FILE(18)
      N=8196
      DO 92 I=5,N
      I1=I-1
      I2=I-2
      I3=I-3
      I4=I-4
      YO(I)=BFHPO*INFLD(I)+BFHP1*INFLD(I1)+BFHP2*INFLD(I2)+AFHP1*YO(I1)
     $+AFHP2*YO(I2)
      XI(I)=ASHP41*YO(I)+ASHP42*XI(I2)+ASHP43*XI(I1)
      XII(I)=XI(I)+XI(I2)-2.*XI(I1)
      XIII(I)=XII(I)+ASHP44*XIII(I1)+ASHP45*XIII(I2)
      XIV(I)=XIII(I)-2.*XIII(I1)+XIII(I2)
      XV(I)=XIV(I)+ASHP46*XV(I1)+ASHP47*XV(I2)
      YPO(I)=XV(I)+XV(I2)-2.*XV(I1)
      GP1=ASLP61*OUTFLD(I1)+ASLP62*OUTFLD(I2)+ASLP63*OUTFLD(I3)+ASLP64
     $*OUTFLD(I4)
      GP2=BSLP60*YPO(I)+BSLP61*YPO(I1)+BSLP62*YPO(I2)+BSLP63*YPO(I3)
     $+BSLP64*YPO(I4)
      OUTFLD(I)=GP1+GP2
      SIG(I)=OUTFLD(I)
C     WRITE(6,1) INFLD(I),YO(I),XI(I),XII(I),XIII(I),XIV(I)
C   1 FORMAT(' A',6G10.5)
C     WRITE(6,2) XV(I),YPO(I),GP1,GP2,OUTFLD(I),SIG(I)
C   2 FORMAT(' B',6G10.5)
```

```
   92 CCNTINUE
      FCLE(1)=YO(8196)
      FCLE(2)=YO(8195)
      FCLE(3)=XI(8196)
      FCLE(4)=XI(8195)
      FOLE(5)=XIII(8196)
      FCLE(6)=XIII(8195)
      FCLE(7)=XV(8196)
      FCLE(8)=XV(8195)
      FCLE(9)=YPC(8196)
      FOLE(10)=YPC(8195)
      FCLE(11)=YFC(8194)
      FCLE(12)=YFC(8193)
      FCLE(13)=OLTFLD(8196)
      FCLE(14)=OLTFLD(8195)
      FCLE(15)=OLTFLD(8194)
      FCLE(16)=OLTFLD(8193)
      FCLE(17)=INFLD(8196)
      FCLE(18)=INFLD(8195)
      RETURN
      END
       FUNCTION ISHIFT (IN,NPLC)
C                RETURNS SHIFTED VALUE OF I*2 WORD IN
C                -VE LEFT,+VE RIGHT SHIFT
C
       INTEGER * 2 IN
       IP=IN
       IF (IP.LT.C) IP=IP+65536
       IF (NPLC.LT.0) GC TC 30
       ISHIFT=IP/(2**IABS(NPLC))
       RETURN
   30  ISHIFT=IP*(2**IABS(NPLC))
       IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
       RETURN
       END
       FUNCTION IMASK (IN,IBL,IBR)
C                MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
       INTEGER * 2 IN,IO
       IO=IN
       IF (IBR.EQ.0) GO TC 50
       IT=ISHIFT(IN,IBR)
       IO=IT
   50  IP=ISHIFT(IO,IBL-15-IBR)
       IO=IP
       IMASK=ISHIFT(IO,15-IBL)
       RETURN
       END
```

```
/*                                                                      VODO4330
//GO.SYSIN DD *                                                         VODO4340
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4350
X COIL AMP IN VOLTS                                                     VODO4360
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4370
Y COIL AMP IN VOLTS                                                     VODO4380
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4390
Z COIL AMP IN VOLTS                                                     VODO4400
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4410
X COIL AMP IN VOLTS                                                     VODO4420
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4430
Y COIL AMP IN VOLTS                                                     VODO4440
CHEN'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VODO4450
Z COIL AMP IN VOLTS                                                     VODO4460
/*                                                                      VODO4470
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=CRDT3A,DISP=(OLD,KEEP),            VODO4480
//             LABEL=(1,NL,,IN),                                        VODO4490
//             DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)                VODO4500
//GO.SYSDUMP DD SYSOUT=A                                                VODO4510
/*                                                                      VODO4520
//                                                                      VODO4530
```

APPENDIX E

MASS STORAGE COMPUTER PROGRAM

```
//TAPEMS5 JOB (2992,0165),'ANTHONY SMC 2123',CLASS=G
//*MAIN ORG=NPGVM1.2992P
// EXEC FORTXCLG
//FORT.SYSIN DD *
C
C     THIS PROGRAM READS DATA FROM A COMPUTER TAPE, NORMALIZES THE DATA
C     BETWEEN +5 AND -5 VOLTS AND STORES IT IN THE IBM 3033 MASS STORAGE
C     SYSTEM FOR FUTURE RECALL. THE DATA IS READ AND TRANSFERRED IN
C     BLOCKS OF 8192 SAMPLES (128 SECONDS OF DATA IN EACH BLOCK).
C           THE ARRAY 'IN' WILL BE USED TO
C           RECEIVE THE DATA PASSED FROM
C           THE SUBROUTINE 'RD' AND THEN
C           TRANSFERRED TO THE APPROPRIATE
C           XXX OR YYY OR ZZZ ARRAY.
      INTEGER*2 IN(16)
      COMPLEX*8 XXX(8192),YYY(8192),ZZZ(8192)
      DATA XXX,YYY/16384*(0.0,0.0)/
      DATA ZZZ/8192*(0.,0.)/
C           THE FOLLOWING SECTION READS THE FIRST
C           ISEC SECONDS OF DATA FROM THE TAPE
C           AND DISCARDS THIS DATA.
C
      ISEC=200
      ITL=ISEC*64
      DO 55 JJ=1,ITL
      CALL RD(20,IN,200,IREC,IRR)
   55 CONTINUE
      IFRAME=8192
C      THE VARIABLE NR SPECIFIES THE NUMBER OF BLOCKS OF DATA TO BE
C      READ FROM THE TAPE AND STORED IN THE MSS.
      NR=19
      DO 70 L1=1,NR
C
C           THE NEXT LOOP READS NR FRAMES OF DATA (EACH FRAME
C           128 SECS LONG AT 64 HZ SAMPLING RATE) USING THE
C           SUBROUTINE RD, PROVIDED BY DR. TIM STANTON OF THE
C           NAVAL POSTGRADUATE SCHOOL.
C
      DO 60 JJ=1,IFRAME
      CALL RD(20,IN,1000,IREC,IRR)
      XXX(JJ)=IN(2)
      YYY(JJ)=IN(3)
      ZZZ(JJ)=IN(4)
   60 CONTINUE
      N=8192
      DO 20 J=1,N
C
C           THE NEXT 4 STEPS CONVERT THE
```

```
C          DATA TC VOLTAGE BETWEEN +5 AND -5 VOLTS ANC SETS THE
C           IMAGINARY PART OF THE COMPLEX NUMBER EQUAL TO ZERO.
C
      XXX(J)=((XXX(J)-2C48.)*5./2048.)-1.36
C     XXX(J)=REAL(XXX(J))
      YYY(J)=((YYY(J)-2C48.)*5./2048.)-1.0
C     YYY(J)=REAL(YYY(J))
      ZZZ(J)=((ZZZ(J)-2048.)*5./2048.)-1.0
C     ZZZ(J)=REAL(ZZZ(J))
   20 CCNTINUE
C
C
C          THE NEXT WRITE STATEMENTS SEND
C          THE CCNVERTED DATA TO MSS
C          FOR FUTURE MANIPULATION AND RECALL.
C
C
C
C
      WRITE(21) XXX
C     WRITE(6,*) XXX(1),XXX(8192)
      WRITE(21) YYY
C     WRITE(6,*) YYY(1),YYY(8192)
      WRITE(21) ZZZ
C     WRITE(6,*) ZZZ(1),ZZZ(8192)
   70 CONTINUE
      WRITE(6,71)
   71 FORMAT(' FINISHED WRITING TO MASS STORAGE')
      ENDFILE 21
      STOP
      END
       SUBROUTINE RD(IUN,IC,IRS,IREC,IRQ)
C
C         THIS PROCEDURE FURNISHED BY DR. TIM STANTCN,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C        IUN=TAPE NUMBER, EG 20
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5
C             /2028.  GIVES VOLTAGE
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C        IREC= COUNTER OF RECORDS (FRAMES CF DATA)
C            BLOCK 512 BITS,   32 BITS = RECORD
C            800 BPI TAPE UNLABLED
C        IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)
C
C
```

```
      INTEGER * 2 IO(16),IP(16)
      DATA IRR /0/
      IF (IREC.EQ.0) IS=0
      IER=0
   20 FORMAT (16A2)
      IF (IS.NE.0) GO TO 50
      READ (IUN,20,END=900) IP
      IREC=IREC+1
   40 IS=IS+1
      IF (IS.LT.17) GO TO 50
      READ (IUN,20,END=900) IP
      IS=1
      IREC=IREC+1
   50 ICH=IMASK(IP(IS),3,0)+1
C     WRITE (6,55) ICH,IS,IUN,IREC
   55 FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)
C
      IF (ICH.NE.1) GO TO 40
      DO 100 I=1,16
      IO(I)=ISHIFT(IP(IS),4)
      ICH=IMASK(IP(IS),3,0)+1
      IF (ICH.EQ.I) GO TO 80
      IER=IER+1
      WRITE (6,70)  IUN,IREC ,I,ICH,IER
   70 FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,
     $ 'ERRORS ',I7)
   80 IS=IS+1
      IF (IS.LT.17) GO TO 100
      READ (IUN,20,END=900) IP
      IS=1
      IREC=IREC+1
  100 CONTINUE
C
      IF (IER.EQ.0) GO TO 150
      IRR=IRR+1
      IF (IRR.LT.IRS) GO TO 120
      WRITE (6,110)
  110 FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')
      IRQ=IRR
      STOP
  120 CONTINUE
      WRITE (6,130) IREC,IRR
  130 FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)
      IER=0
      IRQ=IRR
      GO TO 50
  150 CONTINUE
      RETURN
```

```
  900   WRITE (6,910) IUN,IREC
  910   FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)
        STOP
        END

        FUNCTION ISHIFT (IN,NPLC)
C                RETURNS SHIFTED VALUE OF I*2 WORD IN
C                -VE LEFT,+VE RIGHT SHIFT
C
        INTEGER * 2 IN
        IP=IN
        IF (IP.LT.0) IP=IP+65536
        IF (NPLC.LT.0) GO TO 30
        ISHIFT=IP/(2**IABS(NPLC))
        RETURN
   30   ISHIFT=IP*(2**IABS(NPLC))
        IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
        RETURN
        END
        FUNCTION IMASK (IN,IBL,IBR)
C                MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
        INTEGER * 2 IN,IO
        IO=IN
        IF (IBR.EQ.0) GO TO 50
        IT=ISHIFT(IN,IBR)
        IO=IT
   50   IP=ISHIFT(IO,IBL-15-IBR)
        IO=IP
        IMASK=ISHIFT(IO,15-IBL)
        RETURN
        END
/*
//GO.FT21F001 DD UNIT=3330V,MSVGP=PUB4A,DISP=(NEW,CATLG),
//               DSN=MSS.S2992.LMDT3D,
//               DCB=(RECFM=VBS,BLKSIZE=4096,LRECL=4092),
//               SPACE=(CYL,(8,4))
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=LMDT3,DISP=(OLD,PASS),
//               LABEL=(1,NL,,IN),
//               DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)
//
```

APPENDIX F

MAGFLD COMPUTER PROGRAM

```
//LAMA2CB JOB (1C29,0125),'STEVENS    SMC 2670',CLASS=G
//*MAIN ORG=NPGVM1.1029P,LINES=(65)
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K
//FORT.SYSIN DD DSN=MSS.SYS3.NONIMSL.SOURCE(FOURT),DISP=SHR
//   DD *
      INTEGER*2 IN(16)
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE
      COMPLEX*8 XX(8192),YY(8192),ZZ(8192),TF(8192)
C       THE ABOVE COMPLEX*8 ARRAYS ARE USED TO ORDER INPUT DATA AND
C       INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.
      DIMENSION TIME(8192),FREQ(8192),WORK(16384),FRQ2(8192)
      DIMENSION ZX1(8192),ZY1(8192),ZV1(8192),ZT1(8192)
      DIMENSION ZZX1(65536),ZZY1(65536),ZZV1(65536)
      DIMENSION ZZT1(65536),TIME2(65536)
C       THE 'Z' ARRAYS REPRESENT FREQUENCY DOMAIN (FF TRANSFORMED)
C       MAGNITUDE DATA AND ARE EVENTUALLY CONVERTED TO POWER SPECTRAL
C       DENSITY INFORMATION. ZX1,ZY1,ZV1,AND ZT1 REPRESENT MAGNITUDE
C       VALUES.
      INTEGER K,I4,I5,Q
      REAL SUMX,SUMY,SUMZ,SUMT,AVE1,AVE2,AVE3,AVE4
      REAL CONSTX,CONSTY,CONSTZ,CONSTT
      INTEGER*4 ITB(12)/12*0/
      REAL*4    RTB(28)/28*0.0/
      REAL ALAB(4)/'CH-X','CH-Y','CH-Z','TOT'/
      REAL*8 TITLE(12)
      EQUIVALENCE(TITLE(1),RTB(5))
C       ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING
C       THE VERTSATEC PLOTTER OUTPUT.
      DATA XX,YY/16384*(0.,0.)/
      DATA ZZ,TF/16384*(0.,0.)/
      DATA ZX1,ZY1/16384*0./
      DATA ZV1,ZT1/16384*0./
      DATA TIME,FREQ/16384*0./
      K=0
      I4=1
      I5=1
      CONSTX=0.0
      CONSTY=0.0
      CONSTZ=0.0
      CONSTT=0.0
      SUMX=0.0
      SUMY=0.0
      SUMZ=0.0
      SUMT=0.0
      AVE1=0.0
      AVE2=0.0
      AVE3=0.0
```

```
      AVE4=0.0
      DO 31 IN1=1,65536
      ZZX1(IN1)=0.0
      ZZY1(IN1)=0.0
      ZZV1(IN1)=0.0
      ZZT1(IN1)=0.0
      TIME2(IN1)=0.0
   31 CONTINUE
C       THE NEXT FIVE LINES SERVE AS A TIME DELAY IN STARTING THE
C       DATA ANALYSIS
      ISEC=10
      ITL=ISEC*64
      DO 55 JJ=1,ITL
      CALL RD(20,IN,200,IREC,IRR)
   55 CONTINUE
      IFRAME=8192
      NR=8
      FNR=FLOAT(NR)
      DO 70 L1=1,NR
C       THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO
C      PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN
C      BLOCKS.
C      'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES TO BE AVERAGED.
C      1 SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL
C      OR 256 SECONDS OF DATA.
C
C       THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME
C       STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL
C       CHANNEL
      DO 60 JJ=1,IFRAME
      CALL RD(20,IN,1000,IREC,IRR)
      XX(JJ)=IN(2)
      YY(JJ)=IN(3)
      ZZ(JJ)=IN(4)
   60 CONTINUE
C       THE FOLLOWING SECTION GENERATES THE TIME AND FREQUENCY
C       ARRAYS AND NORMALIZES THE INPUT PCM DATA TO VOLTAGE FORM
C       IN PREPARATION FOR FAST FOURIER TRANSFORM TO THE FREQUENCY
C       DOMAIN.
      N=8192
      FN=FLOAT(N)
      DELTAT=1./64.
      DELTAF=1./(FN*DELTAT)
      DO 20 J=1,N
      TIME(J)=DELTAT*FLOAT(J)
      FREQ(J)=DELTAF*FLOAT(J)
      XX(J)=((XX(J)-2048.)*5./2048.)-1.36
      XX(J)=REAL(XX(J))
```

```
      YY(J)=((YY(J)-2048.)*5./2048.)-1.0
      YY(J)=REAL(YY(J))
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)-1.0
      ZZ(J)=REAL(ZZ(J))
C        'XX' IS THE X-COIL DATA, 'YY' IS THE Y-COIL DATA,
C        'ZZ' IS THE Z-COIL DATA, AND 'TF' IS THE PROJECTION OF THE
C        NORTH-SOUTH COMPONENT (XX) AND THE VERTICAL COMPONENT (ZZ)
C        ON THE TOTAL GEOMAGNETIC FIELD VECTOR.
   20 CONTINUE
      DO 21 J=1,N
      FRQ2(J)=ALOG10(FREQ(J))
   21 CONTINUE
C        THE NEXT FOUR STATEMENTS PERFORM AN FFT ON THE INPUT
C        TIME SERIES DATA. SEE THE WRITEUP ON 'FOURT' FOR
C        FURTHER INFORMATION.
      CALL FOURT(XX,N,1,-1,0,WORK)
      CALL FOURT(YY,N,1,-1,0,WORK)
      CALL FOURT(ZZ,N,1,-1,0,WORK)
C       THE NEXT BLOCK OF STATEMENTS APPLY THE SYSTEM (VOLTAGE TO
C       E-FIELD) TRANSFER FUNCTION TO THE TRANSFORMED FREQUENCY
C       DOMAIN DATA.  THIS BLOCK ENDS AT STATEMENT 9.
C       THE TRANSFER FUNCTION CONVERTS VOLTS TO NANOTESLAS (GAMMAS).
C      ***WARNING*** THIS TRANSFER FUNCTIONS YIELDS AN INACCURATE
C       PHASE.  USE A DIFFERENT TRANSFER FUNCTION IF PHASE INFORMATION
C       NEEDED.
      DO 9 L=1,N
      FRQ=FREQ(L)
      IF(FRQ.LE.25.)GO TO 1
      XX(L)=XX(L)/28.
      GO TO 8
    1 IF(FRQ.LE.15.)GO TO 2
      XX(L)=XX(L)/(105.5-3.14*FRQ)
      YY(L)=YY(L)/(181.32-7.588*FRQ)
      ZZ(L)=ZZ(L)/(177.26-7.484*FRQ)
      GO TO 8
    2 IF(FRQ.LE.10.)GO TO 3
      XX(L)=XX(L)/(5.958*FRQ-30.97)
      YY(L)=YY(L)/(7.166*FRQ-39.99)
      ZZ(L)=ZZ(L)/(6.49*FRQ-32.35)
      GO TO 8
    3 IF(FRQ.LE.7.5)GO TO 4
      XX(L)=XX(L)/(3.492*FRQ-6.31)
      YY(L)=YY(L)/(4.252*FRQ-10.85)
      ZZ(L)=ZZ(L)/(4.044*FRQ-7.89)
      GO TO 8
    4 IF(FRQ.LE.5.)GO TO 5
      XX(L)=XX(L)/(2.6311*FRQ+0.14667)
      YY(L)=YY(L)/(3.012*FRQ-1.55)
```

```
      ZZ(L)=ZZ(L)/(3.184*FRQ-1.44)
      GO TO 8
    5 IF(FRQ.LE.3.)GO TO 6
      XX(L)=XX(L)/(2.6311*FRQ+0.14667)
    7 YY(L)=YY(L)/(2.702*FRQ)
      ZZ(L)=ZZ(L)/(2.92*FRQ)
      GO TO 8
    6 XX(L)=XX(L)/(2.72*FRQ)
      GO TO 7
    8 CONTINUE
      TF(L)=(XX(L)*.5 + ZZ(L)*.866)
    9 CONTINUE
      CALL  FCURT(XX,N,1,1,1,WORK)
      CALL  FCURT(YY,N,1,1,1,WORK)
      CALL  FCURT(ZZ,N,1,1,1,WORK)
      CALL  FCURT(TF,N,1,1,1,WORK)
      DO 57 J=1,N
      XX(J)=XX(J)/FN
      YY(J)=YY(J)/FN
      ZZ(J)=ZZ(J)/FN
      TF(J)=TF(J)/FN
   57 CONTINUE
      DO 56 I3=1,N
      ZX1(I3)=CABS(XX(I3))
      ZY1(I3)=CABS(YY(I3))
      ZV1(I3)=CABS(ZZ(I3))
      ZT1(I3)=CABS(TF(I3))
   56 CONTINUE
C     THE NEXT  44 LINES OF CODE CORRECT DATA BLOCK END JUMPS.
      IF(K.NE.0) GO TO 36
      DO 66 IS=8048,8192
      SUMX=ZX1(IS)+SUMX
      SUMY=ZY1(IS)+SUMY
      SUMZ=ZV1(IS)+SUMZ
      SUMT=ZT1(IS)+SUMT
   66 CONTINUE
      CONSTX=SUMX/144.
      CONSTY=SUMY/144.
      CONSTZ=SUMZ/144.
      CONSTT=SUMT/144.
      DO 67 IS=1,8192
      ZZX1(I4)=ZX1(IS)
      ZZY1(I4)=ZY1(IS)
      ZZV1(I4)=ZV1(IS)
      ZZT1(I4)=ZT1(IS)
      I4=I4+1
   67 CONTINUE
      GO TO 37
```

```
   36 CCNTINLE                                                            LFV01930
      SUMX=0.0                                                            LFV01940
      SUMY=0.0                                                            LFV01950
      SUMZ=0.0                                                            LFV01960
      SUMT=0.0                                                            LFV01970
      DC 68 IS=1,144                                                      LFV01980
      SLMX=ZX1(IS)+SUMX                                                   LFV01990
      SUMY=ZY1(IS)+SUMY                                                   LFV02000
      SLMZ=ZV1(IS)+SUMZ                                                   LFV02010
      SLMT=ZT1(IS)+SUMT                                                   LFV02020
   68 CCNTINUE                                                            LFV02030
      AVE1=SLMX/144.                                                      LFV02040
      AVE2=SUMY/144.                                                      LFV02050
      AVE3=SUMZ/144.                                                      LFV02060
      AVE4=SLMT/144.                                                      LFV02070
      CC 69 IS=1,8192                                                     LFV02080
      ZZX1(I4)=ZX1(IS)+(CCNSTX-AVE1)                                      LFV02090
      ZZY1(I4)=ZY1(IS)+(CCNSTY-AVE2)                                      LFV02100
      ZZV1(I4)=ZV1(IS)+(CCNSTZ-AVE3)                                      LFV02110
      ZZT1(I4)=ZT1(IS)+(CCNSTT-AVE4)                                      LFV02120
      I4=I4+1                                                             LFV02130
   69 CCNTINUE                                                            LFV02140
   37 CCNTINUE                                                            LFV02150
      CC 91 I3=1,8192                                                     LFV02160
      TIME2(I5)=(DELTAT*FLCAT(I3))+(128.0*FLOAT(K))                       LFV02170
      I5=I5+1                                                             LFV02180
   91 CCNTINUE                                                            LFV02190
      K=K+1                                                               LFV02200
   7C CCNTINLE                                                            LFV02210
C     THE FCLLOWING LINES CF CODE PERFORMS A DOUBLE RLNNING PCINT         LFV02220
C     AVERAGE ON THE DATA.                                                LFV02230
      CC 73 L2=1,2                                                        LFV02240
      C=0                                                                 LFV02250
      DC 74 IS=1,65318                                                    LFV02260
      SUMX=0.0                                                            LFV02270
      SUMY=0.0                                                            LFV02280
      SLMZ=0.0                                                            LFV02290
      SUMT=0.0                                                            LFV02300
      DC 75 J=1,144                                                       LFV02310
      SLMX=ZZX1(C+J)+SUMX                                                 LFV02320
      SUMY=ZZY1(Q+J)+SUMY                                                 LFV02330
      SLMZ=ZZV1(C+J)+SUMZ                                                 LFV02340
      SLMT=ZZT1(C+J)+SUMT                                                 LFV02350
   75 CCNTINUE                                                            LFV02360
      ZZX1(IS)=SLMX/144.                                                  LFV02370
      ZZY1(IS)=SLMY/144.                                                  LFV02380
      ZZV1(IS)=SUMZ/144.                                                  LFV02390
      ZZT1(IS)=SLMT/144.                                                  LFV02400
```

```
      Q=Q+1
   74 CONTINUE
   73 CONTINUE
C
C     VERSATEC PLOT OF B - MAGNETIC FIELD (SMOOTHED)
C
      NPTS=1020/DELTAT +1.
C       'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN ORDER FOR
C         THE 0 TO 2041  SECS RANGE TO BE PLOTTED.
C       FOR THE FOLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP
C       FOR THE SUBROUTINE PROCEDURE 'DRAWP'.
      ITB(3)=20
      ITB(4)=8
      ITB(7)=1
      ITB(12)=0
      RTB(1)=0.0
      RTB(2)=0.0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
      ITB(12)=1
      RTB(3)=ALAB(4)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZT1,ITB,RTB)
      ITB(3)=7
      ITB(4)=5
      ITB(12)=0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
      ITB(12)=1
      RTB(3)=ALAB(4)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,TIME2,ZZT1,ITB,RTB)
 3000 FORMAT(6A8)
      STOP
```

```
      END
       SUBROUTINE RD(IUN,IC,IRS,IREC,IRQ)
C
C         THIS PRCCEDURE FURNISHED BY DR. TIM STANTCN,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C        IUN=TAPE NUMBER, EG 20
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SLBTRACT 2048)*5
C               /2028.  GIVES VOLTAGE
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C        IREC= COUNTER OF RECORDS (FRAMES CF DATA)
C            BLOCK 512 BITS,   32 BITS = RECORD
C            800 BPI TAPE UNLABLED
C        IRQ= NUMBER OF ACTLAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       CATA IRR /C/
       IF (IREC.EQ.0) IS=0
       IER=0
 20    FORMAT (16A2)
       IF (IS.NE.C) GO TO 50
       READ (IUN,20,END=900) IP
       IREC=IREC+1
 40    IS=IS+1
       IF (IS.LT.17) GO TO 50
       READ (IUN,20,END=90C) IP
      IS=1
      IREC=IREC+1
 50   ICH=IMASK(IP(IS),3,0)+1
C      WRITE (6,55) ICH,IS,IUN,IREC
 55    FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)
C
      IF (ICH.NE.1) GO TO 40
      DC 100 I=1,16
       IO(I)=ISHIFT(IP(IS),4)
      ICH=IMASK(IP(IS),3,0)+1
      IF (ICH.EQ.1) GO TO 80
      IER=IER+1
      WRITE (6,7C)  IUN,IREC ,I,ICH,IER
 70    FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & CATA CH ',2I4,
     $ 'ERRORS ',I7)
 8C    IS=IS+1
       IF (IS.LT.17) GO TC 100
       READ (IUN,20,END=900) IP
       IS=1
```

```
      IREC=IREC+1
  100 CONTINUE
C
      IF (IER.EQ.0) GO TO 150
      IRR=IRR+1
      IF (IRR.LT.IRS) GO TO 120
      WRITE (6,110)
  110 FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')
      IRQ=IRR
      STOP
  120 CONTINUE
      WRITE (6,130) IREC,IRR
  130 FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)
      IER=0
      IRQ=IRR
      GO TO 50
  150 CONTINUE
      RETURN
  900 WRITE (6,910) IUN,IREC
  910 FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)
      STOP
      END
      FUNCTION ISHIFT (IN,NPLC)
C              RETURNS SHIFTED VALUE OF I*2 WORD IN
C              -VE LEFT,+VE RIGHT SHIFT
C
      INTEGER * 2 IN
      IP=IN
      IF (IP.LT.0) IP=IP+65536
      IF (NPLC.LT.0) GO TO 30
      ISHIFT=IP/(2**IABS(NPLC))
      RETURN
   30 ISHIFT=IP*(2**IABS(NPLC))
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
      RETURN
      END
      FUNCTION IMASK (IN,IBL,IBR)
C              MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
      INTEGER * 2 IN,IC
      IO=IN
      IF (IBR.EQ.0) GO TO 50
      IT=ISHIFT(IN,IBR)
      IO=IT
   50 IP=ISHIFT(IO,IBL-15-IBR)
      IO=IP
      IMASK=ISHIFT(IO,15-IBL)
      RETURN
```

```
      END
/*
//GC.SYSIN DC *
LAMESA VILLAGE ,  4 AUG 83  1802-1819 LOCAL
X CCIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
Y COIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
Z CCIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
TCTAL FIELD  AMP  IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
X CCIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
Y COIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
Z CCIL AMP IN NT
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL
TCTAL FIELD AMP IN NT
/*
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=LMDT3A,DISP=(CLC,KEEP),
//             LABEL=(1,NL,,IN),
//             DCB=(RECFM=FE,LRECL=32,BLKSIZE=512,DEN=2)
//GO.SYSDUMP DD SYSOUT=A
/*
//
```

APPENDIX G

COHER COMPUTER PROGRAM

```
//CCHER32 JOB (2992,0165),'ANTHONY    SMC 2123',CLASS=G                  COHO0010
//*MAIN ORG=NPGVM1.2992P,LINES=(75)                                       COHO0020
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL                              COHO0030
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K                COHO0040
//FORT.SYSIN DD DSN=MSS.SYS3.NONIMSL.SOURCE(FOURT),DISP=SHR               COHO0050
//     DD *                                                               COHO0060
C        THIS PROGRAM READS IN DATA FROM DIGITAL TAPES USING THE          COHO0070
C     SUBROUTINE RD, NORMALIZES THE DATA BETWEEN -5 AND +5 VOLTS,         COHO0080
C     PERFORMS A FOURIER TRANSFORM ON THE DATA INTO FREQUENCY SPACE       COHO0090
C     AND THEN CALCULATES THE COHERENCE OF EACH INDIVIDUAL AXIS BETWEEN   COHO0100
C     THE LAMESA VILLAGE AND CHEW'S RIDGE SITES.                          COHO0110
C                                                                         COHO0120
      INTEGER*2 IN(16)                                                    COHO0130
C      ARRAY 'IN' IS USED IN READING DATA FROM TAPE                       COHO0140
      COMPLEX*8 XXX(8192),YYY(8192),ZZZ(8192)                             COHO0150
      COMPLEX*8 XXL(8192),YYL(8192),ZZL(8192)                             COHO0160
      COMPLEX*8 XXC(8192),YYC(8192),ZZC(8192)                             COHO0170
      DIMENSION CTLX(8192),CTLY(8192),CTLZ(8192)                          COHO0180
      DIMENSION CTCX(8192),CTCY(8192),CTCZ(8192)                          COHO0190
      DIMENSION CTLCX(8192),CTLCY(8192),CTLCZ(8192)                       COHO0200
      DIMENSION COHLCX(8192),COHLCY(8192),COHLCZ(8192)                    COHO0210
C      COMPLEX*8 ARRAYS ARE USED BECAUSE COMPLEX NUMBERS ARE REQUIRED     COHO0220
C      BY THE FOURIER TRANSFORM SUBROUTINE 'FOURT'.                       COHO0230
      DATA CTLX,CTLY,CTLZ/24576*0./                                       COHO0240
      DATA CTCX,CTCY,CTCZ/24576*0./                                       COHO0250
      DATA CTLCX,CTLCY,CTLCZ/24576*0./                                    COHO0260
      DATA COHLCX,COHLCY,COHLCZ/24576*0./                                 COHO0270
      DIMENSION FREQ(8192),FRQ2(8192),WORK(16384)                         COHO0280
      INTEGER*4 ITB(12)/12*0/                                             COHO0290
      REAL*4    RTB(28)/28*0.0/                                           COHO0300
      REAL ALAB(4)/'COHX','COHY','COHZ','TOT'/                            COHO0310
      REAL*8 TITLE(12)                                                    COHO0320
      EQUIVALENCE(TITLE(1),RTB(5))                                        COHO0330
C      ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING       COHO0340
C      THE VERTSATEC PLOTTER OUTPUT.                                      COHO0350
C   THE FOLLOWING LOOP ADVANCES THE DIGITAL TAPE BY ISEC SECONDS.         COHO0360
C                                                                         COHO0370
      ISEC=200                                                            COHO0380
      ITL=ISEC*64                                                         COHO0390
      DO 55 JJ=1,ITL                                                      COHO0400
      CALL RD(20,IN,200,IREC,IRR)                                         COHO0410
   55 CONTINUE                                                            COHO0420
      NR=19                                                               COHO0430
      FNR=FLOAT(NR)                                                       COHO0440
      DO 70 L1=1,NR                                                       COHO0450
C      THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO        COHO0460
C      PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN         COHO0470
C      BLOCKS.                                                            COHO0480
```

```
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES.
C        1 SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL
C        OR 128 SECONDS OF DATA.
C
C         THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME,
C         STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL
C         CHANNEL. FIRST, THE NEXT THREE STATEMENTS READS THE DATA
C         FROM THE LAMESA SITE THAT WAS PREVIOUSLY STORED IN THE
C         IBM 3033 MASS STORAGE SYSTEM.
      READ(21) XXX
      READ(21) YYY
      READ(21) ZZZ
C       SET THE IMAGINARY PART OF THE COMPLEX NUMBERS EQUAL TO ZERO.
      DO 43 I=1,8192
      XXL(I)=REAL(XXX(I))
      YYL(I)=REAL(YYY(I))
      ZZL(I)=REAL(ZZZ(I))
   43 CONTINUE
C       NOW READ THE CHEW'S RIDGE DATA FROM THE COMPUTER TAPE.
      DO 60 JJ=1,8192
      CALL RC(20,IN,1000,IREC,IRR)
      XXC(JJ)=IN(2)
      YYC(JJ)=IN(3)
      ZZC(JJ)=IN(4)
   60 CONTINUE
      N=8192
      FN=FLOAT(N)
      DELTAT=1./64.
      T=FN*DELTAT
      DELTAF=1./T
C     NORMALIZE THE CHEW'S RIDGE DATA BETWEEN +5 AND -5 VOLTS AND SET
C       THE IMAGINARY PART EQUAL TO ZERO. THE LAMESA VILLAGE DATA HAS
C       ALREADY BEEN NORMALIZED IN THE MASS STORAGE PROGRAM.
      DO 20 J=1,8192
      XXC(J)=((XXC(J)-2048.)*5./2048.)
      XXC(J)=REAL(XXC(J))
      YYC(J)=((YYC(J)-2048.)*5./2048.)
      YYC(J)=REAL(YYC(J))
      ZZC(J)=((ZZC(J)-2048.)*5./2048.)
      ZZC(J)=REAL(ZZC(J))
   20 CONTINUE
C       TRANSFORM THE DATA FROM ALL THREE COILS AT BOTH SITES INTO THE
C       FREQUENCY DOMAIN.
      CALL FOURT(XXL,N,1,-1,0,WORK)
      CALL FOURT(YYL,N,1,-1,0,WORK)
      CALL FOURT(ZZL,N,1,-1,0,WORK)
      CALL FOURT(XXC,N,1,-1,0,WORK)
      CALL FOURT(YYC,N,1,-1,0,WORK)
```

```
      CALL FOURT(ZZC,N,1,-1,0,WORK)
C       THE NEXT LOOP IS REQUIRED AFTER TRANSFORMATION. SEE THE WRITEUP
C       FOR THE SUBROUTINE 'FOURT'.
      DO 40 K4=1,N
      XXL(K4)=XXL(K4)/FN
      YYL(K4)=YYL(K4)/FN
      ZZL(K4)=ZZL(K4)/FN
      XXC(K4)=XXC(K4)/FN
      YYC(K4)=YYC(K4)/FN
      ZZC(K4)=ZZC(K4)/FN
   40 CONTINUE
C       THE NEXT LOOP SUMS EACH DATA SAMPLE OVER THE NR BLOCKS OF
C       DATA.
      DO 30 II=1,N
      CTLX(II)=CTLX(II)+CABS(XXL(II)*CONJG(XXL(II)))
      CTLY(II)=CTLY(II)+CABS(YYL(II)*CONJG(YYL(II)))
      CTLZ(II)=CTLZ(II)+CABS(ZZL(II)*CONJG(ZZL(II)))
      CTCX(II)=CTCX(II)+CABS(XXC(II)*CONJG(XXC(II)))
      CTCY(II)=CTCY(II)+CABS(YYC(II)*CONJG(YYC(II)))
      CTCZ(II)=CTCZ(II)+CABS(ZZC(II)*CONJG(ZZC(II)))
      CTLCX(II)=CTLCX(II)+CABS(XXL(II)*CONJG(XXC(II)))
      CTLCY(II)=CTLCY(II)+CABS(YYL(II)*CONJG(YYC(II)))
      CTLCZ(II)=CTLCZ(II)+CABS(ZZL(II)*CONJG(ZZC(II)))
   30 CONTINUE
C       NOW GO BACK AND GET THE NEXT BLOCK OF DATA AND PERFORM THE SAME
C       ANALYSIS ON IT.
   70 CONTINUE
C       CALCULATE THE COHERENCE OF EACH COIL AND THE FREQUENCY SCALE
C       (LOG) IT IS PLOTTED AGAINST.
      DO 44 I4=1,N
      COHLCX(I4)=CTLCX(I4)/(SQRT(CTLX(I4))*SQRT(CTCX(I4)))
      COHLCY(I4)=CTLCY(I4)/(SQRT(CTLY(I4))*SQRT(CTCY(I4)))
      COHLCZ(I4)=CTLCZ(I4)/(SQRT(CTLZ(I4))*SQRT(CTCZ(I4)))
      FREQ(I4)=DELTAF*FLOAT(I4)
      FRQ2(I4)=ALOG10(FREQ(I4))
   44 CONTINUE
C
C
      NPTS=1./DELTAF +1.
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN ORDER FOR
C         THE 0 TO NPTS  FREQUENCY RANGE TO BE PLOTTED.
C        FOR THE FOLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP
C        FOR THE SUBROUTINE PROCEDURE 'DRAWP'.
      ITB(3)=20
      ITB(4)=8
      ITB(7)=1
      ITB(12)=0
      RTB(1)=0.0
```

```
      RTB(2)=0.0
      RTB(3)=ALAE(1)
      READ(5,300C)TITLE
      CALL  DRAWP(NPTS,FRQ2,COHLCX,ITB,RTB)
      RTB(3)=ALAE(2)
      READ(5,300C)TITLE
      CALL  DRAWP(NPTS,FRQ2,COHLCY,ITB,RTB)
      RTB(3)=ALAE(3)
      READ(5,300C)TITLE
      CALL  DRAWP(NPTS,FRQ2,COHLCZ,ITB,RTB)
      ITB(3)=7
      ITB(4)=5
      ITB(12)=0
      RTB(3)=ALAE(1)
      READ(5,300C)TITLE
      CALL  DRAWP(NPTS,FRC2,COHLCX,ITB,RTB)
      RTB(3)=ALAE(2)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,FRQ2,CCHLCY,ITB,RTB)
      RTB(3)=ALAE(3)
      READ(5,3000)TITLE
      CALL  DRAWP(NPTS,FRQ2,CCHLCZ,ITE,RTB)
 3000 FCRMAT(6A8)
      STOP
      END
       SUBROUTINE RD(IUN,IC,IRS,IREC,IRQ)
C
C         THIS PRCCEDURE FLRNISHED BY DR. TIM STANTCN,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C       IUN=TAPE NUMBER, EG 20
C       IO=INTEGER*2 ARRAY, 16 LUNG,(VALUES 0-4095, SLBTRACT 2048)*5
C               /2028.  GIVES VOLTAGE
C       IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C       IREC= COLNTER OF RECORDS (FRAMES CF DATA)
C           BLOCK 512 BITS,    32 BITS = RECORD
C           800 BPI TAPE UNLABLED
C       IRQ= NUMEER OF ACTUAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       CATA IRR /C/
       IF (IREC.EQ.0) IS=0
       IER=0
 20    FORMAT (16A2)
       IF (IS.NE.0) GO TO 50
```

```
      READ (IUN,20,END=900) IP
       IREC= IREC+1
 40    IS=IS+1
       IF (IS.LT.17) GO TO 50
       READ (IUN,20,END=900) IP
      IS=1
      IREC=IREC+1
 50   ICH=IMASK(IP(IS),3,0)+1
C      WRITE (6,55) ICH,IS,IUN,IREC
 55    FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)
C
      IF (ICH.NE.1) GO TO 40
      DO 100 I=1,16
       IO(I)=ISHIFT(IP(IS),4)
      ICH=IMASK(IP(IS),3,0)+1
      IF (ICH.EQ.1) GO TO 80
      IER=IER+1
      WRITE (6,70)  IUN,IREC ,I,ICH,IER
 70    FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,
     $ 'ERRORS ',I7)
 80    IS=IS+1
       IF (IS.LT.17) GO TO 100
       READ (IUN,20,END=900) IP
       IS=1
       IREC=IREC+1
 100   CONTINUE
C
       IF (IER.EQ.0) GO TO 150
       IRR=IRR+1
       IF (IRR.LT.IRS) GO TO 120
       WRITE (6,110)
 110   FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')
       IRQ=IRR
       STOP
 120   CONTINUE
       WRITE (6,130) IREC,IRR
 130   FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)
       IER=0
       IRQ=IRR
       GO TO 50
 150   CONTINUE
       RETURN
 900   WRITE (6,910) IUN,IREC
 910   FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)
       STOP
       END
C
       FUNCTION ISHIFT (IN,NPLC)
```

```
C                 RETURNS SHIFTED VALUE OF I*2 WORD IN
C                 -VE LEFT,+VE RIGHT SHIFT
C
      INTEGER * 2 IN
      IP=IN
      IF (IP.LT.0) IP=IP+65536
      IF (NPLC.LT.0) GO TO 30
      ISHIFT=IP/(2**IABS(NPLC))
      RETURN
 30   ISHIFT=IP*(2**IABS(NPLC))
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
      RETURN
      END
      FUNCTION IMASK (IN,IBL,IBR)
C                 MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
      INTEGER * 2 IN,IO
      IO=IN
      IF (IBR.EQ.0) GO TO 50
      IT=ISHIFT(IN,IBR)
      IO=IT
 50   IP=ISHIFT(IO,IBL-15-IBR)
      IO=IP
      IMASK=ISHIFT(IO,15-IBL)
      RETURN
      END
/*
//GO.SYSIN DD *
LAMESA-CHEW'S RIDGE,4 AUG 83, 1700-1740 LOCAL
X COIL COHERENCE
LAMESA-CHEW'S RIDGE,4 AUG 83, 1700-1740 LOCAL
Y COIL COHERENCE
LAMESA-CHEW'S RIDGE,4 AUG 83, 1700-1740 LOCAL
Z COIL COHERENCE
LAMESA-CHEW'S RIDGE, 4 AUG 83, 1700-1740 LOCAL
X COIL COHERENCE
LAMESA-CHEW'S RIDGE,4 AUG 83,  1700-1740 LOCAL
Y COIL COHERENCE
LAMESA-CHEW'S RIDGE,4 AUG 83,  1700-1740 LOCAL
Z COIL COHERENCE
/*
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=CRDT3,DISP=(OLD,KEEP),
//               LABEL=(1,NL,,IN),
//               DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)
//GO.FT21F001 DD UNIT=3330V,MSVGP=PUB4A,DISP=(OLD,KEEP),
//               DSN=MSS.S2992.LMDT3D,
//               DCB=(RECFM=VBS,BLKSIZE=4096,LRECL=4092)
//GO.SYSDUMP DD SYSOUT=A
```

COHO289C
COHO2900

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4-8